

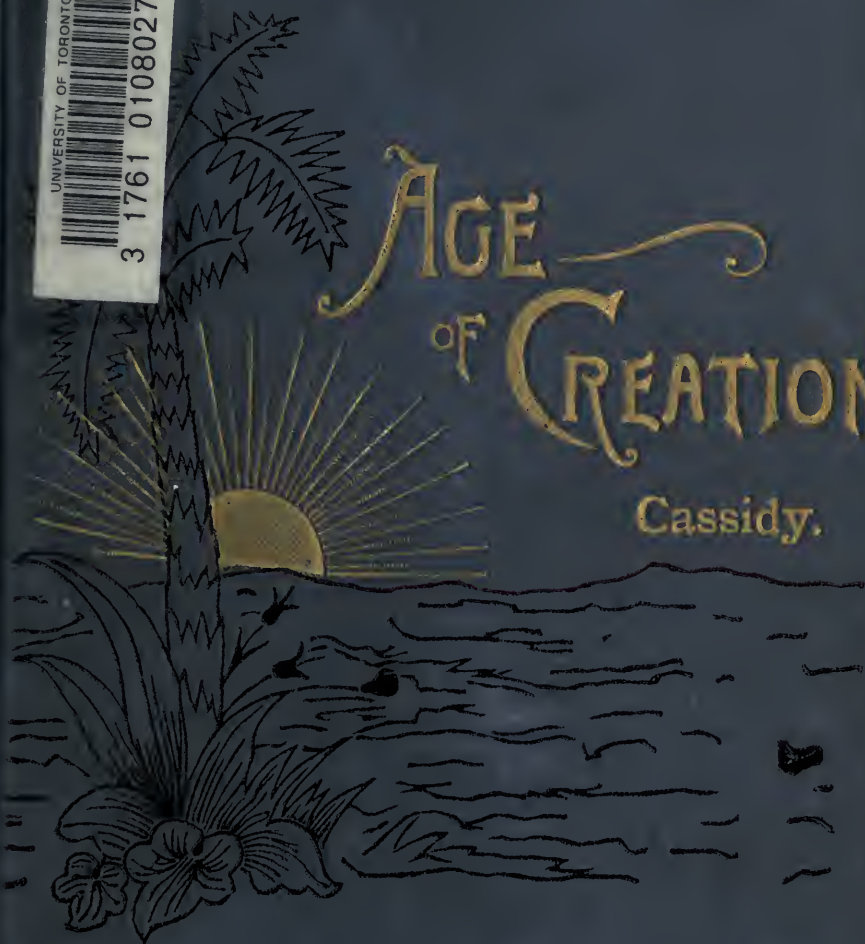
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AGE OF CREATION

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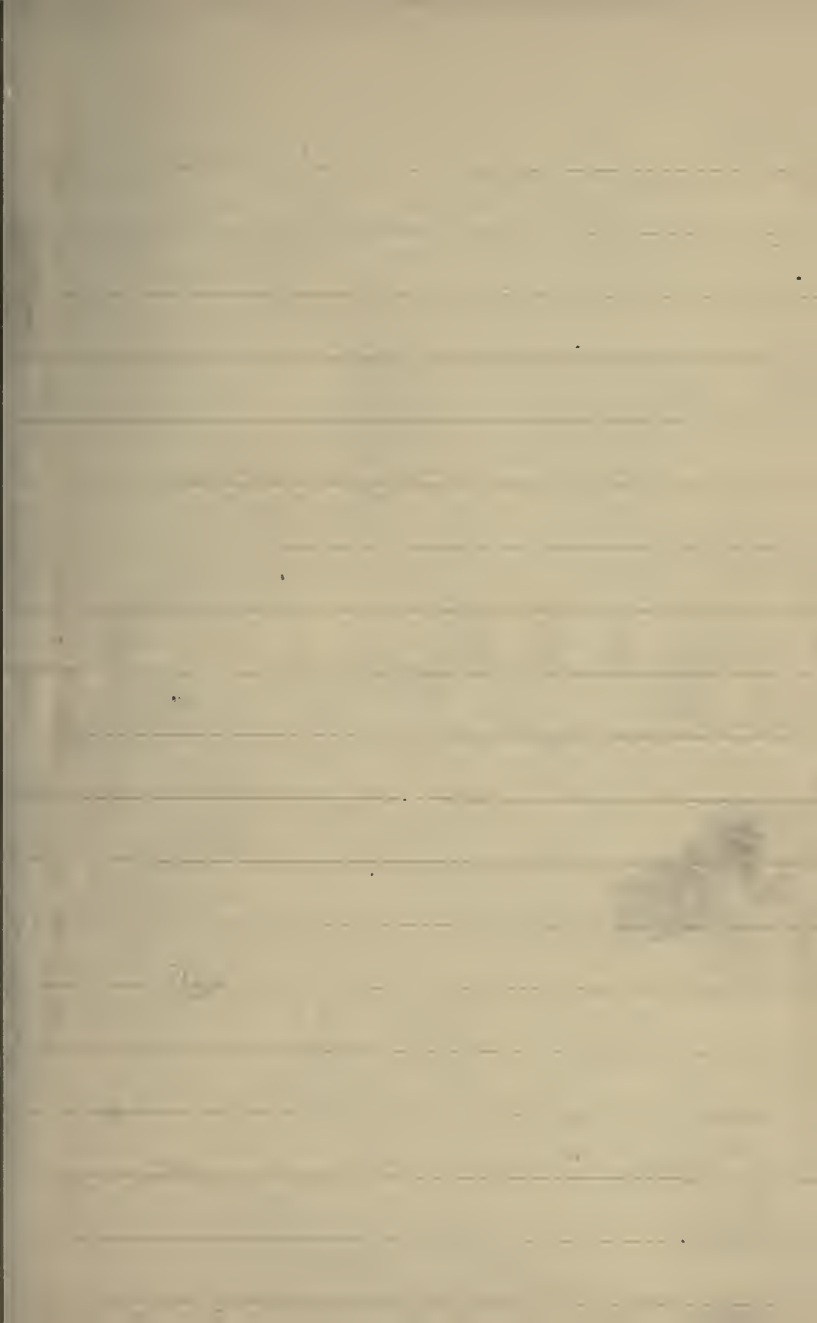
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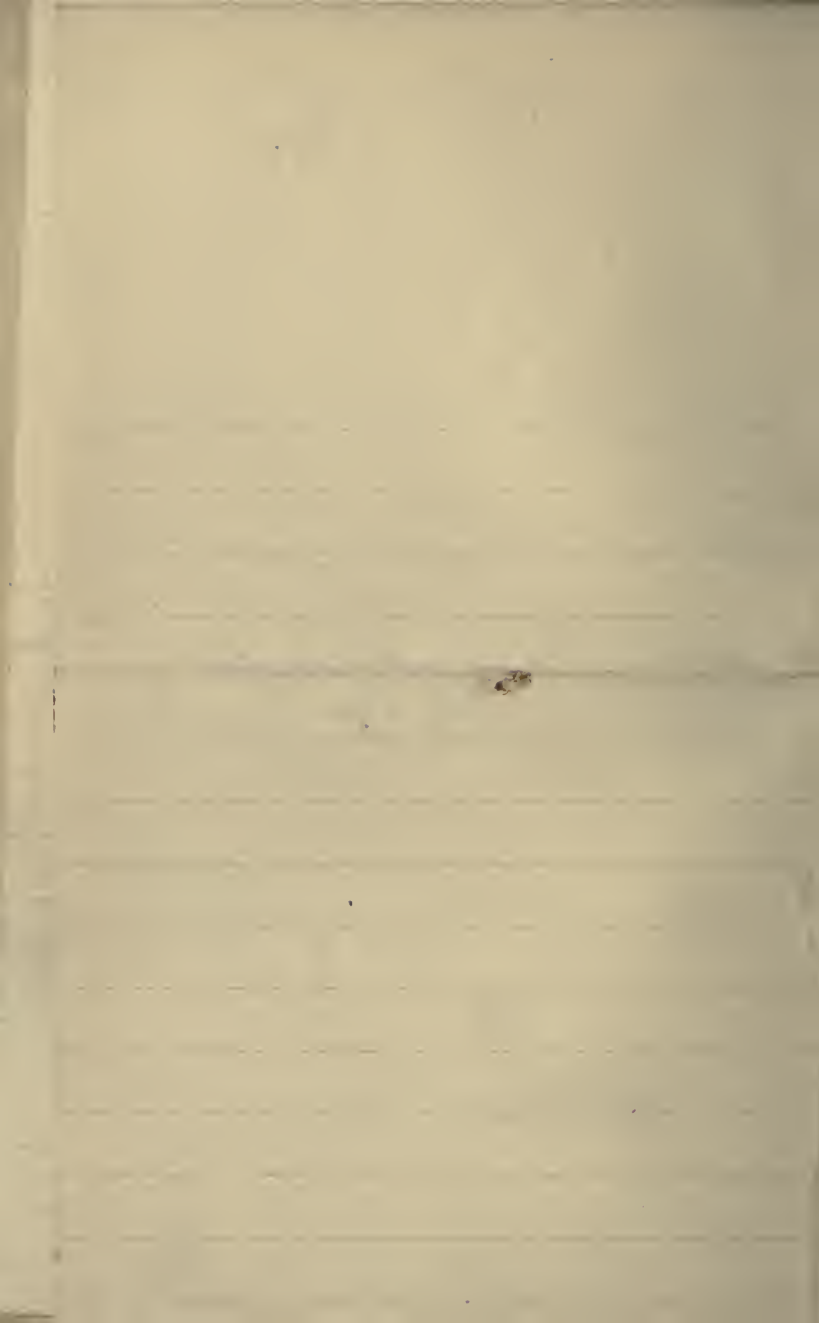
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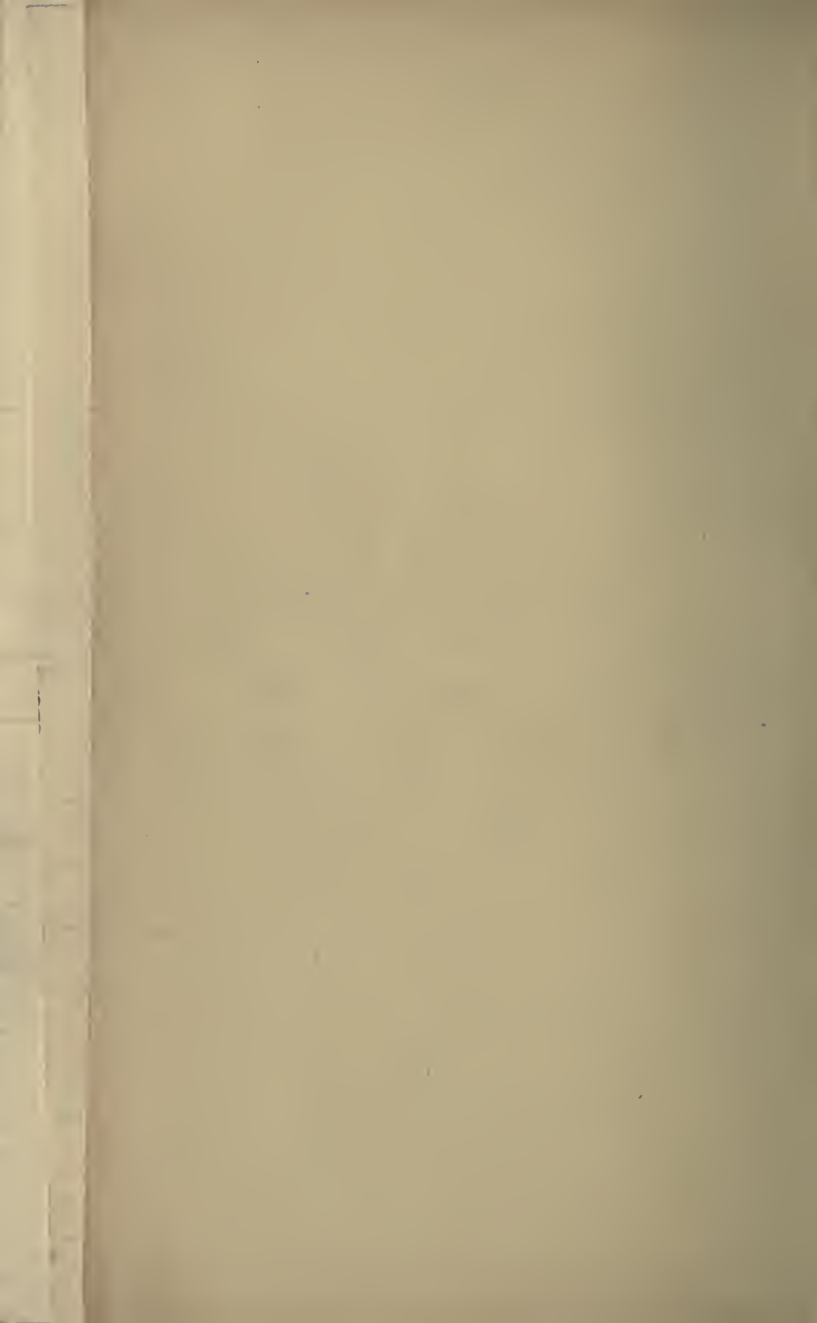
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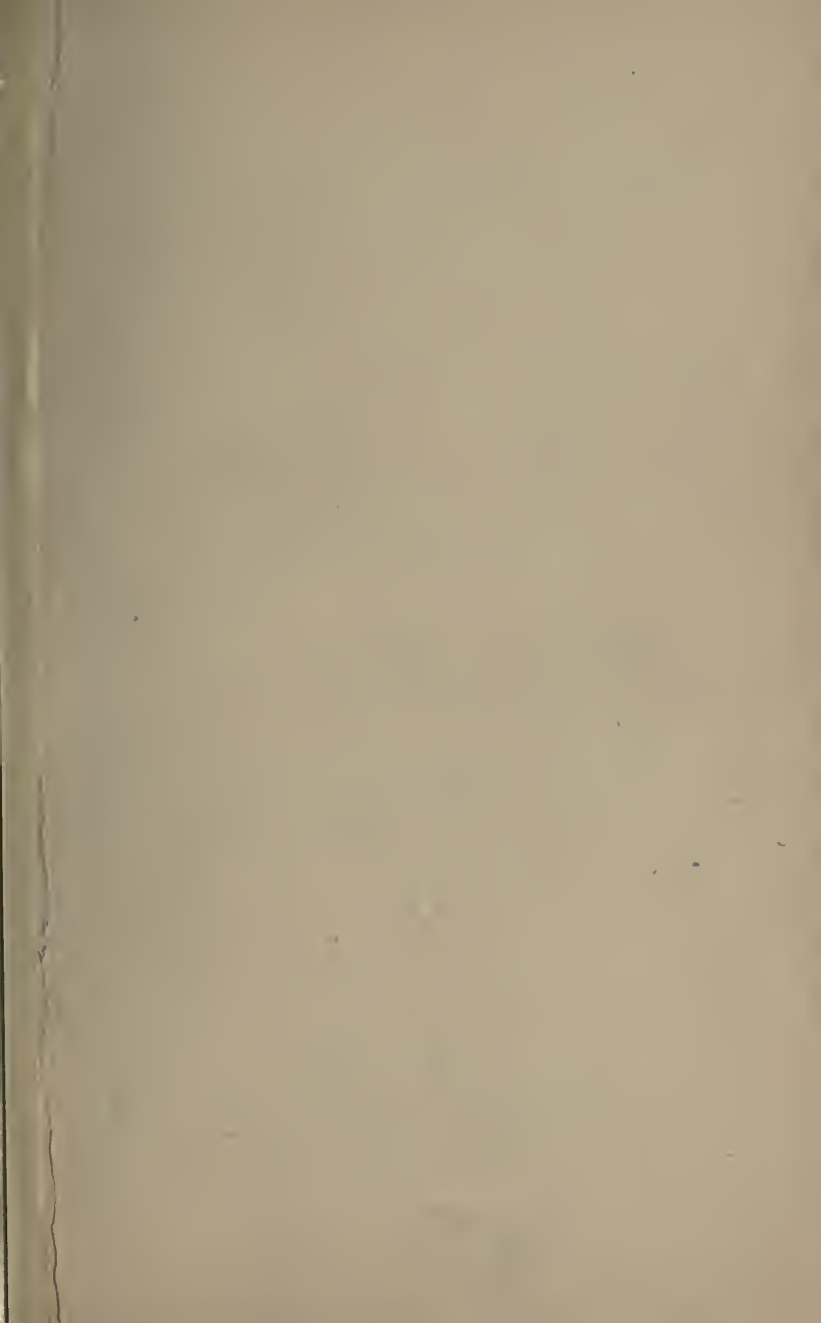
William Cassidy,
1187 Robey Street, Chicago





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AGE OF CREATION.

BY

WILLIAM J. CASSIDY.

“There will be no scientific evidence of God's working in nature until naturalists have shown that the whole creation is the *expression of a thought*, and not the *product of physical agents*.—AGASSIZ.

TORONTO:

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INTRODUCTION.

IN the study of Geology in times past two rival schools, known as the Catastrophists and Uniformitarians, distinguished themselves. The former included Cuvier and a number of others, who maintained that many of the physical features of the earth had been caused by sudden floods and catastrophes. The Uniformitarians, led by Lyell, held that the same had been caused by the forces now in operation, which were the same in all times past, and extended over a period of time so remote as to be beyond the power of human comprehension. As the Catastrophists could show no reason for the occurrence of cataclysms, etc., the doctrine of Uniformitarianism prevailed, and is the one now generally accepted. The object of this work is to point out the results which originally led the earlier geologists to believe in catastrophes, and to suggest causes for the same. Of course, these will at first not only be discredited but scouted as absurd. Experience has shown that it has been always so in the past. But the paradoxical ideas which stood alone

in opposition to all commonly-accepted theories, on investigation generally proved correct. Galileo suffered imprisonment for asserting that the earth moved; Newton's Law of Gravitation did not meet with immediate acceptance; the Glacial Theory of Agassiz was at first stubbornly opposed; while Hugh Miller's descriptions of the fossil fishes of the Old Red Sandstone were first received with doubt and incredulity, and considered by many as altogether imaginative, but confirmed in time as true representations. As the causes herein suggested bring the occurrence of the events within the Scriptural age of the earth, and consequently in conflict with the teachings of Science, a general opposition is expected. But it must be remembered that "to err is human," and it is not impossible that in the past the scientists have erred who first cast doubt upon the Scriptural account of the age and origin of the world.

In the compilation of this book the various geological text-books, and other such scientific works, have been consulted and freely made use of. To credit each authority individually would burden the work with cumbersome references; but where extracts have been quoted the authorities have been given. Among the authors referred to, the works of Agassiz, Lyell, Geikie, Dana, Dawson, Page and others on Geology have been

used, as well as the astronomical works of Herschel, Dick, Proctor, Newcomb, Guillemin, Ledger and numerous others. In the descriptive matter, therefore, there is nothing new, the originality being solely in the causes attributed to the origin of unexplained mysteries. A few are suggestive in order that attention may be drawn to the subjects, and the whole made the work of a careful investigation from an entirely different point of view than at present taken, which may lead to confirmation and a final solution, which must sooner or later come to pass.

"I am as certain as of my own existence that Science, in a more extended compass, long, very long, before it is perfect, will be the surest, stoutest, most irresistible, apology for the Bible in the whole history of facts and arguments since controversy began. It will prove the Mosaic Creation, the authenticity of the Pentateuch; it will establish the Deluge and Noah's ark, and it will render all Joshua credible; the miracles of Moses and the Red Sea. It will make every syllable of the Old and New Testaments as clear and certain to our minds and souls as hunger and thirst, food and raiment, pain and pleasure, are to our bodies."—LORD SHAFTESBURY.

AGE OF CREATION.

PART I.

CHAPTER I.

THE VOICE OF NATURE.

“**I**N the beginning God created the heaven and the earth.” Such is the brief, expressive, and most authentic account known of the formation of the universe. It was *created*. It was the production of a thought emanating from the mind of a Great, Unseen, Illimitable Being. Science has searched in vain for a more comprehensible cause; but the deeper the thought, the more profound the research into the workings and teachings of nature, the more does it become evident that the whole system is the design and handiwork of an omnipotent Creator.

Let us take a brief glance at this mighty universe, of which the earth forms such a ponderous, and yet at the same time comparatively insignificant, part. Look upwards. Far as the eye can reach appears a vast

expanse of ethereal space, in which the sun shines by day and the moon and stars by night. The sun equals in volume 1,273,000 bodies the size of the earth, and is distant from it about 92,000,000 miles. It is a massive luminous globe 880,000 miles in diameter, and its influence is known to extend for a distance of 3,000,000,000 miles, yet the space it occupies in the heavens appears to us but a few inches! What, then, must be the size of the remaining space, to which there is no conceivable limit?

The stars that shine by night are worlds of enormous magnitude, millions of miles apart, the nearest of them being twenty millions of millions of miles distant from the earth. Beyond the power of sight, beyond the range of the most powerful telescope, there lies a dim and impenetrable abyss, the depth of which cannot be fathomed by the mind's imagination!

The moon is 240,000 miles distant from the earth. "This distance, great as it is, is little more than one-fourth of the diameter of the sun's body, so that the globe of the sun would nearly twice include the whole orbit of the moon; a consideration wonderfully calculated to raise our ideas of that stupendous luminary."*

Let us examine a drop of infused water. By the aid of a microscope it is seen to be a living world, teeming with animal life of the most varied and grotesque forms, the infinitude of which cannot be comprehended no more than the magnitude of the heavens. Yet this diminutive world and the stupendous globes

* Herschel's "Outlines of Astronomy," p. 263.

of space are the handiwork of that one Invisible and Incomprehensible Being.

Everywhere may be seen evidence of God's working in nature. In the growth and development of organized beings; in their geographical distribution through space; and in the progressive succession of created animal life from the lowest form to the crowning work of creation. The mysterious and awe-inspiring presence of nature may be felt in the pervading sense of majestic grandeur on the lofty and rugged mountain; in the feeling of repose and serenity occasioned in the quiet and peaceful valley below; in the moaning and sighing of the tree-tops in the depths of the forest; or in the motionless calm or terrific sublimity of the mighty ocean. The strange, unmistakable voice of nature permeates the whole universe, exciting admiration for the wondrous works of a Supreme Being, and constantly reminding us that "The hand that made them is Divine."

"Alone with the waves, on a starry night,
My thoughts far away on the infinite;
On the sea not a sail, not a cloud in the sky,
And the wind and the waves with sweet lullaby
Seem to question in murmurs of mystery,
The fire of heaven, the waves of the sea.

"And the golden stars of the heaven rose higher;
Harmoniously blending their crowns of fire,
And the waves which no ruling hand may know,
'Midst a thousand murmurs, now high, now low,
Sing, while curving their foaming crests to the sea,
It is the Lord God! It is He."

—*Victor Hugo.*

CHAPTER II.

THE EARTH.

THE relation of the heavenly bodies to each other in the solar system, the causes which produce day and night, the regularity of the seasons, and other similar phenomena, are subjects which astronomy has long since mathematically and satisfactorily demonstrated. The earth is known to be the third of a series of planets which revolve around the sun, and though of enormous magnitude, is but an infinite atom in the complex system of which it forms a remarkable and prominent part. It is a globe 8,000 miles in diameter, surrounded by a shell or crust apparently as thin in proportion to its bulk as the globular covering of a soap bubble! The interior is supposed to be a glowing, incandescent mass of molten material, of a temperature vastly beyond the range of any source of heat existing upon its surface. The doctrine of the igneous nature of the interior of the earth is generally believed in by geologists, though many tenaciously maintain a belief in a solid or nucleated centre. But there is a mass of undisputed evidence in favor of the former, not the least among which is the undeniable fact that volcanoes exist all over the globe, from the Arctic to the Antarctic regions, emitting fire,

ashes and melted lava. The lavas are all of a similar character, indicating their origination from the same universal source. Another argument is the fact that, in excavations made in the crust of the earth, the temperature increases with the descent, varying slightly according to the nature of the surrounding strata. At but a comparatively short depth the degree of subterranean temperature attained shows that it could have only emanated from an igneous source. There are a few plausible objections against the theory of a central fire in the earth, but let it be temporarily granted that it is so. The thickness of the earth's crust has been variously estimated at from ten to thirty miles; but compared with the diameter of the globe itself this is but an insignificant fraction. It is composed of earths, minerals and rocks, which were originally of a soft, coherent nature, but afterwards solidified by the agency of the elements. These have been ruptured and upturned by convulsions arising from the working of fire beneath, or gradually, as by the agency of water, etc. The form of the earth is that of a spheroid, or a globe slightly flattened at the poles, showing that it first obtained its axial motion, and was rapidly whirled around while in a plastic condition. It revolves on its axis from west to east once in twenty-four hours, each half of the globe being alternately presented to the sun, producing day and night. On account of its being bulged out in the centre the attraction of the sun is greater at the equator than at the poles; and instead of remaining upright the

earth is drawn down in a stooping or inclined position, this inclination being twenty-three and a-half degrees from its perpendicular. This obliquity produces the seasons, owing to the heat of the sun acting in a direct line. The earth revolves around the sun in $365\frac{1}{4}$ days, and as the rays of the latter in a direct line strike the oblique regions the different variations in light and heat are the result. The moon also revolves on its axis, and has a motion around the earth, and is carried with it in its circuitous course around the sun. The planets of the solar system are held in their place by the attractive power of the sun. The strength of this attraction varies according to the distance between the bodies, and in agreement with the following laws: "Suppose that one ball is drawing another towards it with a certain force, and that the distance between their centres is one foot; if the distance is increased to two feet the force of the attraction is reduced to a fourth of what it was; if the distance is made three feet the attraction becomes a ninth; if four feet, a sixteenth; and so on—the diminution being always as the squares of the distance; that is, the distances multiplied by themselves. The distance from the centre of any round mass of matter to its surface is called its semi-diameter; that is, the half of its diameter or thickness. If, then, there are two such masses, a large and a small, and if we ascertain how many semi-diameters of the larger the smaller is distant from it, and multiply that number by itself, the result shows how many times the attraction at this distance is less

than if the two were close together. The moon, for instance, is distant 240,000 miles from the earth, or as much as sixty semi-diameters of the earth; 60 multiplied by 60 gives 3,600; consequently the attraction exercised by the earth upon the moon is a 3,600th part of what it would exercise upon the same mass at its own surface."*

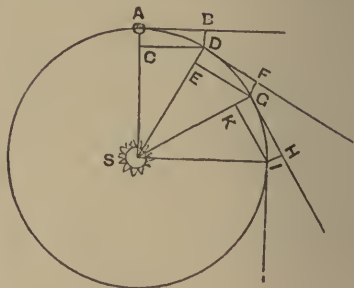
So that, according to the law of gravitation, if the distance between the earth and the sun were increased to a certain extent, and the earth removed farther away from the sun, the attraction would be lessened to such a degree that the earth would lose its present obliquity and remain in a perpendicular or upright position. The nicety and harmony of arrangement in the whole planetary system is in entire accordance with fixed laws in nature; by these laws they are sustained in their respective positions, and in the least deviation or departure from them disastrous results would follow.

Floating through illimitable space, and suspended upon nothing, the earth performs its annual revolution around the sun in the manner following:—

"Let us suppose the earth at its creation to have been projected forwards. We know, from the laws of motion, that if no obstacle impeded its course it would proceed interminably in the same direction and with a uniform velocity. Let *A* represent the earth and *S* the sun. We shall suppose the earth arrived at the point in which it is represented in the figure, having

* Chambers' "Introduction to the Sciences," p. 15.

a velocity which would carry it on to *B* in the space of one month, whilst the sun's attraction would bring it to *C* in the same space of time. Reasoning upon the laws of uniform motion we might hastily conclude that the earth would move in the diagonal *AD* of the parallelogram *ABCD*, as a ball struck by two forces will do. But the force of attraction is continually acting upon our terrestrial ball, and producing an incessant deviation from a course in a straight line, and thus converts it into a course in a curve line.

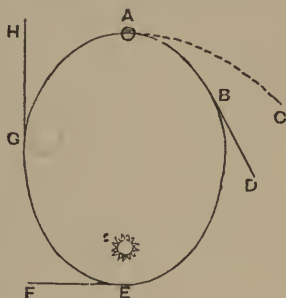


“Let us detain the earth a moment at the point *D*, and consider how it will be affected by the combined action of the two forces in its new situation. It still retains its tendency to fly off in a straight line; but a straight line would now carry it away to *F*, whilst the sun would attract it in the direction *DS*. In order to know exactly what course the earth will follow, another parallelogram must be drawn in the same manner as the first—the line *DF* describing the force of projection, and the line *DE* that of attraction—and it will be found that the earth will proceed in the curve line *DG* drawn in the parallelogram *DFGE*; and if we go on throughout the whole of the circle, drawing a line from the earth to the sun to represent the force of attraction, and another at a right angle to it to de-

scribe that of projection, we shall find that the earth will proceed in a curve line passing through similar parallelograms till it has completed the whole of the circle. The attraction of the sun is the centripetal force, which confines the earth to a centre; and the impulse of projection, or the force which impels the earth to quit the sun and fly off, is the centrifugal force.

“We have described the earth as moving in a circle merely to render the explanation more simple; for in reality the centripetal and centrifugal forces are not so proportioned as to produce circular motion, and the earth’s orbit or path around the sun is not circular, but elliptical or oval.

“Let us suppose that when the earth is at *A* its projectile force does not give it a velocity sufficient to counterbalance that of gravity, so as to enable these powers conjointly to carry it around the sun in a circle; the earth, instead of describing the line *AC*, as in the former figure, will approach nearer the sun in the line *AB*. Under these circumstances, it will be asked, what is to prevent our approaching nearer and nearer the sun till we fall into it?—for its attraction increases as we advance towards it. There also seems to be another danger. As the earth approaches the sun the direction of its motion is no longer perpendicular to that of attraction,



but inclines more nearly to it. When the earth reaches that part of its orbit at *B* the force of projection would carry it to *D*, which brings it nearer the sun, instead of bearing it away from it; so that, being driven by one power, and drawn by the other, towards this centre of destruction, it would seem impossible for us to escape. But with God nothing is impossible. The earth continues approaching the sun with an accelerated motion till it reaches the point *E*, when the projectile force impels it in the direction *EF*. Here, then, the two forces act perpendicularly to each other, and the earth is situated as in the preceding figure; yet it will not revolve around the sun in a circle for the following reasons: The centrifugal force increases with the velocity of the body; or, in other words, the quicker it moves the stronger is its tendency to fly off in a right line. When the earth arrives at *E* its accelerated motion will have so far increased its velocity, and consequently its centrifugal force, that the latter will prevail over the force of attraction, and drag the earth away from the sun till it reaches *G*. It is thus that we escape from the dangerous vicinity of the sun; and as we recede from it both the force of its attraction and the velocity of the earth's motion diminish. From *G* the direction of projection is towards *H*, that of attraction towards *S*, and the earth proceeds between them with a retarded motion till it has completed its revolution. Thus the earth travels around the sun, not in a circle, but an ellipsis, of which the sun occupies one of the foci; and in its course the earth alternately approaches and recedes from it, so that what at first

appears a dangerous irregularity is the means by which the most perfect order and harmony are produced. The earth, then, travels on at a very unequal rate, its velocity being accelerated as it approaches the sun, and retarded as it recedes from it.”*

The centripetal force, therefore, is the attraction of the sun which confines the earth to a centre; and the centrifugal force is the impulse of projection, or the force which impels the earth to fly off in a straight line instead of going on in a circle. Thus, “thrown outwards by one power, and drawn inwards by another, they have settled into paths where the two forces balance each other, so that they can neither go further from the sun, nor come nearer to him, than they do.”† And in this manner the planets have revolved since their creation. Referring to these luminaries, it is recorded in the Psalm of Solomon, 18th chap. v. ult., as quoted by Whiston in his “Life of Josephus,” “They have not wandered from the day that He created them; they have not forsaken their way from the ancient generations, unless it were when God enjoined them (so to do) by the command of His servants.” Here exceptions are pointed out, from which it may be inferred that in some remote period of the past they have wandered from their courses and forsaken their way, but at what time and under what circumstances will be referred to further on. In the meantime a brief glance may be taken at some of the peculiarities connected with the crust of the earth.

* Library of Useful Knowledge. † “Introduction to the Sciences,” p. 19.

CHAPTER III.

THE GLACIAL DRIFT.

IN the hurry and bustle of every-day life how few stop to contemplate, even for a moment, the wondrous phases of animate and inanimate nature! The mind has become so engrossed with other thoughts, and the eye so accustomed to the surrounding scene, that for them the rocks and stones, animals and birds, trees and flowers, have no charm, and the grandeur and magnificence of the starry heavens have long since lost their attractiveness. But there are others who have devoted their lives to an enthusiastic study of nature, overcoming obstacles in the face of almost insurmountable difficulties, and from the combined result of their labors we are enabled to penetrate the dim vistas of the past, and read the life-history of successive generations of animals and plants that "lived, and moved, and had their being" in the dim and twilight days of the earth's infancy, even ere the sun and moon had been created. The broken and upturned rocks, boulders and gravel, speak in silent voices, and tell of bygone days when tremendous floods and mighty cataclysms swept the face of the earth with cyclonic fury, and suddenly obliterated nearly all animal and vegetable life, and consigned their remains to a sepul-

chre of unhewn rock to point out and tell to future generations the history of their past existence. The story of their birth dates back to the time of creation, and includes the great geological breaks in the earth's crust that confront the observer at every step, the origin of which has heretofore remained an unsolved problem, and constituted a great gap in the scientific knowledge of the world.

If the crust of the earth be perpendicularly penetrated it will be found composed of layers or beds of rocks, piled one on another, like the leaves of a book. These are called stratified rocks, and they rest upon others of a hard, crystalline and sparkling appearance, known as unstratified or igneous rocks, as having been produced by the agency of fire. Like the leaves of a tattered book, some of the layers are broken, crumpled and torn, while others are partly, and in some places altogether, missing, but still bound together and following each other in continuous regularity. Each of the layers represents a period of time in the history of the earth's formation, and by way of illustrations the stratified rocks contain remains of petrified plants and animals, known as fossils, which once lived and existed on the earth when these rocks were forming.

The following table will explain the system of arrangement adopted by geologists respecting the formation of the earth's crust. Though most of the groups subjoined are sub-divided in geology, the subdivisions are omitted for the sake of simplicity. The tabulation varies slightly in different countries, but

the system peculiar to British and American geologists is the one herewith annexed :

<i>Systems.</i>	<i>Groups.</i>	<i>Periods.</i>	<i>Cycles.</i>
QUATERNARY	{ Present. Recent.	Cenozoic.	} Neozoic.
TERTIARY	{ Boulder Formation. Pliocene.		
	{ Miocene. Eocene.		
	{ Cretaceous.		
SECONDARY	{ Jurassic. Triassic.	Mesozoic.	} Palæozoic.
PRIMARY	{ Permian. Carboniferous.	Palæozoic.	
	{ Old Red Sandstone.		
	{ Silurian. Cambrian.	Eozoic.	
	{ Laurentian.		

Resting on the top of the sedimentary rocks in many countries, and immediately below the surface of the earth, there lies the first great geological obstruction—a vast, unstratified, heterogeneous deposit of sand, clay and gravel, from one to several hundred feet in depth, known to geologists as the Glacial drift. Where it came from and the manner in which it was deposited is now generally agreed upon; but the causes which produced it have hitherto remained an unsolved mystery.

Enclosed in this deposit are found fragments of rock which have been transported for a long distance, and bear on their surfaces certain peculiar marks known to have been caused by some powerful grinding, abrasive action. They are of all dimensions and forms, some being partially rounded and others broken into angular shapes, and water-worn. Broken trunks of

trees and branches are often included, and all are mixed together in the utmost confusion.

This accumulation has been thoroughly sorted, and may be classified under the heads of the Glacial, Inter-glacial, and Post-glacial deposits, according to the manner in which they have been laid down, either at the beginning, during, or at the end of the period known as the Glacial epoch.

The nature of the whole deposit varies considerably in the different districts in which it is found, but there is an almost universal similarity throughout.

The lowest deposit consists of unstratified clay or loam, containing numerous rounded or broken blocks of stone, and is known as till, or boulder clay. The surfaces of these stones are often polished, striated and grooved, and they are altogether foreign to the immediate locality in which they are found, having been transported from similar rocks at a greater or less distance from their present positions.

The surfaces of many of the stones found in the boulder clay present a remarkable appearance. Those consisting of fine, hard rock, are generally striated and scratched along the whole length of their flat sides, and these are occasionally crossed by similar markings in opposite and various directions. All appear to have been scratched or scored by the friction of sand and gravel, and ground smooth by a mighty and tremendous force, which propelled and pushed the entire mass with a steady and continuous movement in an onward course, and in the one direction.

The texture of the till is very fine and of great tenacity, forming a tough cement by which the numerous enclosed stones of all dimensions, from the size of the smallest pebble to a large boulder, are firmly knit together into a solid mass. The underlying rocks upon which it rests generally present the various characteristics of modern ice glaciation, according to the nature of the material of which they are composed. It often attains a thickness of 100 feet in low-lying districts, and has been found at a height of 2,000 feet above the level of the sea.

The Inter-glacial deposits consist of beds of marine and fresh water material, in which are found shells of existing species, many of them of a boreal character, indicating that they had been transported from more northern regions. Beds of laminated sand are a principal feature. These consist of a white sandy loam, of a structureless appearance, seen sometimes in flexed, contorted and complicated foldings, somewhat resembling the gun material known as "twist." Though evidently deposited in an even and horizontal manner, many of them are bent and curved, and as apparently confused as the foam of an angry sea. The deposits overlying the till often partake of remarkable structural forms, such as mounds and ridges, which stretch across the plains, along the sides of hills, and in the valleys. Some of the ridges range from twenty to thirty feet in height, and are about fifty feet in diameter at the base. Many of them extend in nearly a uniform course for several miles, while others appear

to have been whirled around into a crateriform shape, enclosing a basin-like hollow within. In Scandinavia they are known as ösars, and in Ireland and Scotland as eskers and kames respectively.

"Some writers," says Archibald Geikie, "have compared these features to the submarine banks formed by the pathway of tidal currents near the shore. Others have supposed them rather to be of terrestrial origin, due to the melting of the great snowfields and glaciers, and the consequent discharge of large quantities of water over the country. But no very satisfactory explanation of them has yet been given."*

In North America the Post-glacial period is known as the Champlain epoch. During this period the brick earths and valley gravels were formed. These are accumulations of fine mud and loam, in the form of a sediment, deposited along the banks of ancient river courses, and at various heights above the present level of the river. This fluviatile deposit is especially adapted for brickmaking, and is known as brick-earth or loess, and along the banks of the Mississippi, and the Rhine in Europe, this deposit is spread over a large area, and attains a thickness of several hundred feet. The valleys of nearly all the extinct rivers and channels in North America contain this deposit to a greater or less extent. The valley gravels are also fluviatile deposits, but consist of coarse sand and gravel found at different levels in the river valley, having been formed at periods when the river bed existed at those

* Geikie's "Text-book of Geology."

places. These are known as high-level and low-level gravels. The Post-glacial deposits consist of an upper boulder clay, with water-worn stones, intermingled with sand, gravel or silt, and occasionally contains marine shells, bones of extinct animals, etc.

These three deposits—the Glacial, Inter-glacial and Post-glacial, consisting of rubbish, gravel, clay, sand, stones, rocks and organic remains—combined form what is known as the Boulder formation. It is also known as the Glacial drift, as evidently having been deposited by the aid of floating ice.

There is no other known cause whereby they could have been possibly transported to their present sites, except by the agency of powerful currents of water, impelled by some sudden and tremendous force that originally blasted the rocks and detached them from their former places in the mountains.

Enormous blocks of stone have been dropped on the rugged sides of lofty mountains, where they remain perched in a position of the most threatening insecurity. Many of these are foreign to the locality in which they are found, and have been transported from their original positions, across surrounding plains and over ranges of hills and other apparently insurmountable obstructions. The flanks of the Jura Mountains, in Switzerland, are the resting place of great numbers of erratic blocks, which are known to have crossed the vast plain of Switzerland from their former places in the Alps. As the Jura Mountains are principally formed of limestone, the crystalline granitic boulders

found on their sides could only have originated there by transportation. Many of these have been carried for a distance of about sixty miles. Above Lake Neufchâtel, at a height of 800 feet, a chain of boulders extends for many miles, containing thousands of erratic blocks of enormous dimensions; and in many other mountainous regions of Europe similar instances are known to exist. About two miles west of Neufchâtel a gigantic block of transported rock, known as Pierre à Bot (Toadstone), is estimated to weigh about 3,000 tons. According to French measurement it is 50 feet long by 20 feet wide. Its height is 40 feet and its contents about 40,000 cubic feet, and it is known to have travelled for a distance of 66 miles. On the Chaseron enormous blocks are seen at a height of 3,000 feet, and on the southern side of the Alps great masses of erratics are high up on the mountain sides, in the vicinity of Lake Como, over which they have been originally transported. In Europe the detritus from the mountains of Scandinavia is scattered over an estimated area of 1,200,000 square miles, lying between the German Ocean on the west and the White Sea on the east—a distance of about 2,000 miles in length, and ranging from 400 to 800 miles wide. On the plains of Russia, Prussia and Poland erratic blocks of immense size are met with belonging to the primitive rocks of Scandinavia. In St. Petersburg an errant boulder forms the pedestal to the statue of Peter the Great. Its weight when found in its previous resting place was estimated at 1,500 tons.

In North America erratic blocks are strewn almost over the entire country as far south as 40° north latitude. In Canada the transported rocks and boulders are scattered over the face of the country in thousands. In the Qu'Appelle Valley, in the Canadian North-West, an enormous erratic block protrudes above the surface of the ground to a height of 14 feet, and is 78 feet in length. Another of limestone, below the Moose Woods, is estimated at 60 feet in circumference and 16 feet in height. Thousands of smaller boulders are strewn over the country many miles from their source of origination.

In the eastern parts of the United States transported rocks of great dimensions are seen, some of them estimated to weigh from 3,000,000 to 4,000,000 pounds. They have been carried bodily over a long distance from their original place in the mountains from which they were formerly detached. Trains of boulders have also been traced to their native source, and other long and narrow lines of broken fragments and detritus are seen to extend continuously for hundreds of miles. In the State of New Hampshire numerous detached rocks of great dimensions are found. The Churchill Rock, of Nottingham, as described by Prof. Hitchcock, is estimated to contain 75,000 cubic feet, its dimensions being 62 feet long, 40 feet wide, and 40 feet high. It weighs about 6,000 tons. Another in Whitingham, Vermont, weighs about 3,000 tons. Many boulders have been found at an altitude of over 5,000 feet above the sea level, and their source of origin known to be many miles away.

The Drift presents many curious and interesting features. In Britain and other parts of Europe many of the hills are worn and denuded on their northern and north-western sides, exposing a rough and craggy surface, while their southern and south-eastern slopes are generally covered with a thick accumulation of sand and gravel. The whole appearance thus presented is known as "crag and tail."

Another remarkable form of abrasion in connection with the Drift is seen in the phenomena known as "giants' kettles." These are deep, eroded holes in the solid rock, formed by the grinding action of sand, mud and stones carried by water issuing from crevasses over precipices in waterfalls, and descending in one particular spot. The cavities become filled up with the detritus and remain there after the water has disappeared. In Norway great numbers of these excavations exist, having been filled to the brim with sand, gravel and stones deposited by the Drift.

Another peculiar feature in connection with the Drift is observed in its geographical distribution. The true till is found on only one side of the globe, extending from the North Pole as far south as 38° and 40° degrees north latitude, and disappearing in the equatorial region. West of the Rocky Mountains, in America, along California and the coast, the till is absent. In northern Asia and Siberia, on the eastern part of the globe, the true boulder clay is also missing. The whole of Northern Europe, Russia, Scandinavia, and the elevated portions of Central Europe, and the

temperate and polar regions of North America, are the countries principally affected by the Drift. In the northern parts of Asia there are no such deposits, though in the same latitude as other westerly regions where the Drift occurs. This is a remarkable and apparently unaccountable fact, why such deposits could have accumulated only on one side of a swiftly rotating globe such as the earth, revolving with an equatorial speed of over 1,000 miles an hour, and not on the other.

From the foregoing a tolerably fair idea may be had of the deposits known as the Glacial drift; but there are many peculiarities connected with it.

In the first place, unlike the rocks below it, the formation is mainly unstratified, that is, there are no continuous layers or beds, but a heterogeneous mass of gravelly rubbish, looking as if it had been scraped together, ranging from 50 to 800 feet thick. The till, or lower portion, is extremely hard and tough, and an intercalary layer is found between the two deposits. In the upper deposit there are rocks of immense size and weight, some having been estimated to weigh from one to four million pounds.

Many of the stones found in the till are strangely marked, striated and scratched with lines parallel to the longest diameter, and are found on the mountains as well as in the valleys and on the plains.

In the till clay, sand, stones, boulders and gravel are found mixed together in the utmost confusion, "higgledy-piggledy, pell-mell," and in some instances

the underlying rocks have been decomposed and melted as if by fervent heat.

The deposit is thick in the valleys and thin on the hills, ridges and elevations.

Some of the boulders are not water-worn nor rounded. Neither are they angular, for the projecting points have been ground off.

The surface rocks on which the drift is deposited are polished smooth, scratched, striated and furrowed in two opposite directions.

Only the northern and western sides of hills and mountains are scarified and striated, while the south bears little or no striae whatever.

The till is not found all over the world, but only on the northern portion of the western side of it, being absent in the equatorial regions and the eastern hemisphere.

The entire deposit is generally unfossiliferous, that is, it is almost devoid of organic remains; and while fossils are found above and below, few traces of pre-existent or contemporaneous life are found in till whatever.

The period in which it was deposited was accompanied by a sudden change in climate, by which the polar regions became habitable and the tropical regions colder.

A universal change of level also took place, by which the land in many parts became completely submerged and afterwards re-elevated.

Finally, aerolites, or meteoric stones, have been found in the drift.

Lyell cites a circumstantial account from "Erman's Archives of Russia" respecting the finding of a mass of meteoric iron in the auriferous alluvium of the Altai: "Some small fragments of native iron were first met with in the gold washings of Petropawlowsker, in the Mrassker Circle; but though they attracted attention, it was supposed that they must have been broken off from the tools of the workmen. At length, at a depth of thirty-one feet five inches from the surface, they dug out a piece of iron weighing $17\frac{1}{2}$ pounds, of a steel grey color, somewhat harder than ordinary iron, with a small proportion of nickel, as is usual in meteoric stones. It was buried in the bottom of the deposit where the gravel rested on a flaggy limestone. Much brown iron, as well as gold, occurs in the sand gravel, which appears to be part of the extensive auriferous formation in which the bones of the mammoth, the rhinoceros (*tichorhinus*) and other extinct quadrupeds abound."*

Where all this gravelly rubbish came from, and the cause of its heterogeneous peculiarities, had long been a puzzle and a conundrum to geologists. All the older geologists were agreed that it was the result of violent action of some kind; and it is now generally admitted that the deposit was caused by ice, and hence it is known as the Glacial drift. The proofs of this fact are overwhelming. The surface of the rocks underlying the glacial deposits in the more northern regions present the similar scratched and polished

* Lyell's "Elementary Geology," p. 145

characteristics of the stones found in the boulder clay. Where the superficial deposits have been immediately removed the exposed surface of the underlying rock is found to be grooved and deeply striated in a manner almost identical with similar markings now known to be the result of the grinding action of moving ice. That the grooved, scratched and striated rocks were thus marked by glaciers is evident, for no other cause is at present known by which they could be produced. In mountainous countries where glaciers exist, the rocks over which they have passed are found to be identically striated, and to bear the same marks of glaciation as those existing on the mountain tops, and in the valleys of the regions affected by the Drift, and consequently could have been produced only in the same manner. From the direction of the striæ on the surface of the rock beds, and the accumulation of Drift material left behind, the movements of the ice-sheet by which they were produced have been traced. By this means it has been found that great oscillations of level have accompanied the march of the floating ice. The extent of the vertical movements has been ascertained by Prof. Ramsay to exceed 2,000 feet. The British Isles are known to have undergone a great change of level, amounting to 500 feet in some parts of Scotland, and from 1,200 to 1,400 feet in Central England and North Wales. In America, also, a similar change of level is known to have occurred. Many mountainous districts formed centres of distribution from which the ice passed

downward, and radiated in various directions into the surrounding neighborhood. The entire body of ice moved steadily forward in one general direction—from north-west to south-east—over broad and extensive plains, down steep ravines, and up lofty precipices almost to the summits of many mountain peaks. The vast ice-clad mountain chain of the Alps formed a central axis, down the sides of which the glaciers slid and spread in every direction over the low undulating land lying at its base and across the adjoining plains. In Scandinavia the ice is computed to have reached an elevation of about 7,000 feet. Great Britain was completely submerged beneath the floating icebergs. In the Highlands of Scotland many mountains are striated to a height of over 3,000 feet; and the progress of the ice-sheet and its various deflections can be distinctly traced as it advanced in its onward march, grinding the entire surface of the country, and rounding and grooving the summits of the lower hills and prominences that lay in the course over which it moved. From Scotland the torrent of ice descended into Ireland and the Irish Sea, and at the same time the ice-jam filled the basin of the North Sea to overflowing, and spread over the entire length and breadth of the British Isles. The rough and jagged edges of the hardest crystalline rocks were ground down and worn perfectly smooth by the grinding action of the moving ice. These rounded hummocks are known as *roches moutonnées*, and are found over entire valleys as well as on the mountain side and the plains. Numer-

ous small lakes and pools are enclosed within the erosive depressions between these clustering domes, and many of the rocks still retain distinctly their ice-worn characteristics, as though their abrasion had been but of recent occurrence.

In North America the results of Glacial action are seen in grand magnitude. The highest mountains formed but a slight barrier, and the advancing icebergs swept from Greenland and the Arctic seas over the face of the country with apparently the greatest ease. East of the Rocky Mountains the Dominion of Canada was utterly devastated by a continuous sheet of marching ice, which moved from the Arctic regions downward over the northern continent. Every movable thing was carried forward, and enormous quantities of *debris* strewn for miles over the tract passed over by the mighty avalanche of destruction. In the Missouri coteau of the North-West, as shown by G. M. Dawson, a mass of Glacial *debris* and scattered boulders extends diagonally across the central region, with an average breadth of from thirty to forty miles, for a distance of eight hundred miles, and marks the forward course of the vast and stupendous ice-sheet in that direction. Onward it plowed, grooved and tore up the entire surface of the country, as it steadily continued on its southward march. Over every obstruction it pushed with irresistible force, clambering up the Laurentian Hills, and sliding over their summits with the same uniformity of force by which it crossed the vast and

more level portion now forming extensive plains. The mountain tops of Labrador were levelled down, and the rocky fragments carried away and scattered for miles with inconceivable fury. Gigantic boulders of granite and gneiss were torn from their sides, and grooved or polished smooth by the stupendous torrent of marching ice which passed over their surfaces. The steep banks of the River St. Lawrence, along the lines of its various rapids, are composed almost entirely of boulder clay; and the numerous striated and ice-worn hummocks of gneiss along its shores retain the tell-tale marks that the ice had been there. Southward it sped onward into the United States, and in the eastern portion ground and scratched the Catskill Mountains to a height of 3,000 feet. At a height of nearly 6,000 feet the White Mountains show unmistakable proof that the icebergs had also been there, and smashed and detached from the mountain sides enormous boulders weighing as much as 4,000,000 pounds. Gradually the onward movement of the ice ceased as it approached the temperate regions, the boulders became diminished in size, and further south towards the equatorial regions all traces of the drift disappeared. After a lapse of time another somewhat similar movement took place from the Antarctic regions, by which the land in the southern portion of the globe became deluged and strewn with diluvial deposits as far north as the 41st degree of south latitude. In the equatorial regions, including the torrid and adjacent portions of the temperate zone, the Drift deposits are

almost entirely wanting, showing that in each instance they were polar phenomena, and disappeared as each approached the equator.

But where did all this ice come from? and how would it be carried up 6,000 feet on the sides of the mountains? If the drift had been gradually deposited under water deep enough to float icebergs, it would present some evidence of stratification; but this is not the case, for the boulder, sand, gravel and clay are all mixed together in the utmost confusion. Besides, when the ice melted the heavier stones would first fall to the bottom, then the smaller stones, and finally the finer material. Then these deposits would fall evenly on the surface below in layers, conforming to the inequalities of the ground, instead of being thick in the valleys and thin on the hills and ridges. How could the ice have been high enough to groove and scratch the rocks on the tops of the highest mountains and in the lowest valleys at the same time? And where would a sheet of ice 6,000 feet thick come from? and where would the force come from to drive it into the rocks in the valleys and on the mountains and striate them? Again, the rocks are striated in an extraordinary manner. They cross each other in two diametrically opposite directions, in the form of the letter X. These are some of the conundrums in connection with the ice theory.

As to the cause which produced the downward march of the ice, Norton says: "When we come to study the cause of these phenomena we find many perplexing

and contradictory theories in the field. A favorite one is that of *vertical elevation*. But it was impossible to admit that the circle enclosed within the parallel of 40 degrees—some 7,000 miles in diameter—could have been elevated to such a height to produce this remarkable result. This would be a supposition hard to reconcile with the present proportion of land and water on the surface of the globe, and with the phenomena of terrestrial contraction and gravitation.”*

“Exactly how the Glacial period was introduced,” observes G. M. Dawson, “or by what phenomena its beginning was marked, it is now very difficult, if not impossible, to tell. Nor can any reliable estimate of its duration be formed, for the effect of the later periods has been, not only to obliterate more or less many of the former physical features of the country, but such as to cover up and conceal those which antecedent glaciation may have produced. *There is nothing to show, however, that the glacial conditions prevailed for a very long period* before that of the greatest subsidence, nor do we meet with any phenomena not easily explained by the action of the waters and ice during the subsidence and subsequent elevation. There is also reason to believe that *the elevation took place rapidly*, as compared with the subsidence.”†

In “The World before the Deluge” M. Charles Martins says: “The most violent convulsions of the solid and liquid elements appear to have been themselves only the effects due to a cause much more

* “Climate and Time,” p. 391.

† “Geology and Resources of the 49th Parallel,” p. 236.

powerful than the mere expansion of the pyrosphere ; and it is necessary to recur, in order to explain them, to some new and bolder hypothesis than has yet been hazarded. Some philosophers have *believed in an astronomical revolution* which may have overtaken our globe in the first age of its formation, and have modified its position in relation to the sun. They admit *that the poles have not always been as they are now, and that some terrible shock displaced them*, changing at the same time the inclination of the axis of the rotation of the earth."

There is distinct evidence of two great convulsions having occurred during the period known as the Glacial epoch, and after describing them Figuier says: "The two cataclysms of which we have spoken surprised Europe at the moment of the development of an important creation. The whole scope of animated nature, the evolution of animals, was suddenly arrested in that part of our hemisphere over which these gigantic convulsions spread, followed by the *brief but sudden submersion of entire continents*. Organic life had scarcely recovered from the violent shock when *a second* and, perhaps, severer blow assailed it. The northern and central parts of Europe, the vast countries which extended from Scandinavia to the Mediterranean and the Danube, were visited by a period of sudden and severe cold ; the temperature of the polar regions seized them. The plains of Europe, now ornamented with luxurious vegetation developed by the heat of a burning climate—the boundless pastures on which

herds of great elephants, the active horses, the robust hippopotamus, and great carnivorous animals grazed and roamed—became covered with a mantle of ice and snow.”

Arch. Geikie says: “That the axis of the earth’s rotation has successively shifted, and that consequently the poles have wandered to different points on the surface of the globe, has been maintained by geologists as the only possible explanation of certain remarkable conditions of climate which can be proved to have formerly obtained within the Arctic circle. Even as far north as latitude $81^{\circ} 45'$ abundant remains of a vegetation indicative of a warm climate . . . have been found *in situ*. It is contended that where these plants lived the ground could not have been permanently frozen or covered for most of the year with thick snow. In explanation of the difficulty it has been suggested that *the North Pole did not occupy its present position*, and that the locality where the plants occur lay in more southerly latitudes.”*

Would a sudden upward and downward shift of the North Pole, with the occurrence of an interval of time between the events, produce the Glacial epoch, and explain the various peculiarities connected with the drift? Let us see.

* Geikie’s “Text-book of Geology.”

CHAPTER IV.

ANCIENT WATER MARKS.

HIGH up on many a mountain side, far above the level of the surrounding country, may be seen long parallel rows or terraces, composed of pebbles, stones, sea shells and gravel. Seen at a distance they appear like chalk lines drawn across the face of the hills; but a closer examination proves their true character. They are ancient sea beaches! Here the waters once found their level, and after their retreat left their imprint as clear and distinct as if the recession had just recently taken place. There is no mistaking their nature. Long lines of undisturbed stones and boulders, covered with adherent barnacles and other littoral organic remains, bear undoubted testimony of a former high-water mark. Not only on the beaches, but below them, in what was formerly the water-bed, are found the remains of organisms attached in positions where they had formerly grown. In addition to these, rocky cliffs bearing marks of littoral and sub-littoral life, many hundred feet above the existing sea, furnish direct proof of a change of level in the surrounding land.

Many centuries have passed since the waves of these vast inland seas beat against the mountain side, and

washed up the littoral that now marks its former level. Bleached in the summer's sun and winter's snow of ages past, they still remain to corroborate the solution of that great geological mystery—the Glacial epoch. These raised beaches are generally known as terraces, and are to be met with in various parts of the globe on many maritime coasts, as well as in inland countries where no sea at present exists. One great peculiarity common to them all is the fact that they are of recent origin, and of a comparatively modern geological date. Not until the later Tertiary period, after all the previously existing rocks had been formed, did these great changes in level take place; and it is a well-known and established geological fact that their formation was contemporaneous with the Drift.

The terraces of Great Salt Lake, in Utah, south of Salt Lake City, along the flanks of the Wasatch Mountains, present a fine illustration of terraces in general. A group of level lines, parallel to each other, encircle the base of the mountains for miles, crossing obstructions and following the declivities in the mountain side with remarkable and unvarying regularity. Great Salt Lake lies 4,218 feet above the sea level, covering an area of 2,360 square miles, and has an average depth of twenty feet, its deepest part being about eight fathoms. The highest terrace is 940 feet above the present surface of the lake, consequently when the water stood at that shore line its surface was 5,158 feet above the sea level. The water then had an outlet northward through Snake River into

the Pacific Ocean, for a gap in the basin rim north of the present shore of the lake has been found to correspond in height with that of the terrace line. This fact, together with the presence of fresh-water shells on the terrace, proves conclusively the absence of salt water, and that the lake was then a vast inland sea, like one of the present inter-oceans of Canada. Here the lake stood at the time of the first disturbance, as indicated by the presence of moraines and Glacial *debris* at the edge of the terrace. The Wasatch Mountains rise to a height of from 10,000 to 12,000 feet, and are covered with snow throughout the greater part of the year. The polished, grooved and scored rocks of the valleys prove conclusively that the snow and ice formerly descended from the mountains; and the great accumulations of moraine detritus on the highest shore line show that the glaciers descended to the edge of the water. No other known cause but a sudden upward movement of the North Pole could have instantaneously precipitated the snow-caps of these mountains into the lake below, and at the same time changed the level of the water to a lower terrace.

Great Salt Lake is at present about eighty miles long by thirty-two wide. It has no visible outlet, and receives the melted snows of the Wasatch and other ranges through the rivers on the north and south, Bear River on the north being 300 miles in length. The lake lies in a slight depression of the vast desert plain which stretches to the west from the base of the mountain range. The shore is on a level with the sur-

rounding plain, which graduates slowly out under the lake with remarkable uniformity. Its waters contain twenty-two per cent. of salt, and are entirely destitute of ichthyic life, though fish are found in its inlets, but none in the lake itself. The entire margin of the lake is completely encrusted with salt, and the water has a heavy, placid and lifeless appearance. As the waters of the lake were proved to have been formerly fresh when they stood at the highest terrace, it is evident that they now owe their present salinity to the Drift. This evidently has been caused by the deposition of salt from an overflow of the waters of the ocean, which became land-locked in the valleys after a change of level occurred. The lake then sank to the level of the lowest terrace, and below the outlet by which it had been formerly drained into the Pacific Ocean. With the occurrence of the second vertical disturbance the waters again rose to the second terrace, and have gradually fallen to their present position, from which they are slowly diminishing, notwithstanding the many contributions received from the surrounding streams, so great and rapid is the extent of its evaporation.

The well-known terraces of Glen Roy, in Scotland, a result of the Glacial epoch, bear similar testimony to a former change of level in Great Britain at the same geological period. The upper terrace is 1,139 feet above tide level, the second 1,059 feet, and the third 847 feet.

The terraces bordering on the great lakes of Canada

indicate that in former times the waters stood much higher than they do now. There is substantial and undoubted proof that Lake Superior stood at least 180 feet higher than at present. Lakes Michigan and Huron were then flooded to a height of 200 feet above their present level. The whole of Western Ontario was submerged, and the waters stretched westward for twenty-seven miles into the State of Michigan, where an ancient beach indicates their termination in that direction. A large part of Illinois was also inundated.

At Mackinac Island a perpendicular limestone wall, 150 feet high, by which it is surrounded, is eroded and worn by exposure to the action of the waves from bottom to top. On the main plateau of the island stands the well-known "Sugar Loaf," all that is left of a similar formation by which it was formerly surrounded. Up to the very pinnacle this old monument bears the well-known smooth characteristics peculiar to the erosive action of water.

North and west of Toronto the presence of a former high-water level is marked by ridges or sand bars, running parallel with Lake Ontario at different altitudes, ranging from 100 to 600 feet above its present water level. These ridges have been formed according as the water retreated, and are not confined to Toronto, but similar ones are found in the neighborhood of all the great lakes. If the water again attained its former level, all the cities bordering on the lakes would be entirely submerged, and Toronto would be buried at the bottom of a sea, the waters of which would roll

over two hundred feet above the top of the spire of St. James' Cathedral, on King Street, its present height being 316 feet.

Another ridge lies along the south side of Lake Ontario, and has been found to exactly coincide with the summit of the country between the St. Lawrence and the Ottawa, both being of an equal height—392 feet.

From observations made on the great lakes of North America, and the formation of their ancient beaches, Dr. Andrews, of Chicago, has demonstrated the manner in which the Drift occurred. He points out the changes of level which formerly took place, and the rapidity with which the lakes fell and rose, and establishes an identification of the alluvium, known as loess, with the period of the formation of the middle beach. "The loess," he observes, "is not a continuation of the boulder clay, as is often supposed; on the contrary, it is separated from the true drift by a stratum of vegetable mould, marked with subærial denudations, showing that a period of dry land and vegetation intervened between the close of the Drift and the submergence called the loess." He also shows that the Drift period closed abruptly by the sudden retirement of the waters. "It should be observed," he says, "that our lakes have existed ever since the close of the Drift period, a time which is rather sharply defined, because the close of the Drift in this region occurred with a suddenness unusual in geological phenomena."

Of the formation of the three concentric beach lines

of Lake Michigan, Dr. Andrews shows that the "upper beach, which appears all around the lakes where not worn away by subsequent erosion, and which originally must have been level, has now been thrown into a sinuous form, *showing that the country has undergone changes of level since that time.*" As this shore line must have been originally level it is held that its present distorted grade can only be due to flexures of the strata of the continent occurring since the beach was laid down. The fall of waters from the line of the upper beach appears to have been very sudden. This he explains by a peculiarity in the contour of the deposit, which is of a uniform nature in all the sand shores of this part of the coast. Going out into the lake the bottom gradually descends from the water line to a depth of about five feet, when it rises again on a recession from the shore, and then descends towards deep water, forming a subaqueous ridge or "bar" parallel to the beach, and some ten or twenty rods from the shore. The upper beach preserves its old bar perfectly, as if the lake had left it but yesterday. This is an indication that the waters receded rapidly, for had it occupied even two months in receding from the bar the waves would have torn it to pieces; and furthermore, there are no sand ridges between the upper and middle beaches. The waves of Lake Michigan act upon their shores with tremendous force, and they could not possibly effect a slow retreat without leaving marks which no time could erase. When a subsidence took place the waters fell,

not to the middle beach, but to the lower one. They "fell to about the present level so suddenly that they not only left the subaqueous 'bar' almost undisturbed, but they did not throw up a single intermediate beach line, which, at the rate of sand deposit prevailing in this region, would have been visible if there had been a pause even of six months. The waters remained here long enough for a thin stratum of peat to form, and then rose again over the soil bed and deposited the middle beach upon it." The deluge of the middle beach, he has discovered, went temporarily much higher, and deposited a stratum of muddy gravel over the black soil which had accumulated on the upper beach. The water remained at this upper limit for a very brief period—not long enough to lay down a definite shore line. The higher part of this inundation he identifies as the true analogue of the loess deluge. "From the upper edge of the middle beach, the water receded very slowly . . . throwing up, where the sand supply was most abundant, numerous parallel ridges. It then fell, perhaps, ten feet more pretty rapidly, to the upper part of the present beach leaving a continuous valley between the middle and the modern sands. This last recession, however, was not so sudden as that from the upper line, as shown by the fact that the subaqueous bar was demolished by the retiring wave action, and a considerable amount of sand was left between the middle and lower beaches."

When in America Sir Charles Lyell visited Toronto, and afterwards, in referring to the ridges and other

marks of ancient levels between it and Lake Simcoe, said: "With the exception of the parallel roads or shelves in Glen Roy, and some neighboring glens of the Western Highlands, in Scotland, I never saw so remarkable examples of banks, terraces and accumulations of stratified gravel, sand and clay maintaining over wide areas so perfect a horizontality as in this district north of Toronto."*

As a definite result of general geological research it has been ascertained that a perfectly equable shift of level to a height of at least 2,000 feet has been effected in times past on the surface of the globe. This conformity in the change of level is not confined to any particular locality, but extends all over the world—in America, Britain, France, Switzerland and Scandinavia. Its universal equality of range shows that the disturbing movement was not of a local nature. This has been proved in comparing the lands of one country with those of another, by which some of them have been found exactly to coincide with each other. Respecting this wonderful coincidence of parity and uniformity of level, Robert Chambers long ago remarked: "There is, nevertheless, enough to justify a question regarding uniformity of level, not only throughout North America, but also—bold as the idea may, in the present state of knowledge and of hypothesis, appear—the old and the new continents. It has certainly appeared to myself, to say the least, a promising prognostic of some important new views

* "Travels in North America," Vol. II., p. 106.

regarding a chapter in the past history of the globe, when, it being granted that terraces and benches of land are marks of ancient levels of the sea, I find that a tendency to a bench form or plateau, at sixty, or from sixty to seventy, feet above present high water, exists on the coasts of the United States and in the Gulf of St. Lawrence as it does in Britain; that conspicuous terraces in Britain and in France, at 188 and 392 feet, are repeated in America; that there, also, at about 545 feet, are several repetitions of a decided and most notable Scottish terrace, and that Scott built his house of Abbotsford on an ancient sea beach beside the Tweed, which finds an analogue in the first of the grand ridges sweeping from east to west behind Toronto."*

The peninsula of Scandinavia presents some striking proofs of a former change of level. At a distance of at least fifty miles inland from the sea coast the rocky sides of the Norwegian fjords bear the usual terrace lines to a height of over 600 feet above the level of the sea. The Siberian coast east of the River Lena, for a distance of 600 miles, is characterized by similar markings. So, also, are the islands of Nova Zembla and Spitzbergen. In South America, along the western coast, terraces have been traced on the frontier of Bolivia at various heights above the sea. In the mountain regions of Chili they exist at 1,000 feet, and as high as 1,300 feet near Valparaiso.

The whole South American continent shows con-

* "Ancient Sea Margins," p. 316.

vincing evidence of a former elevation and subsidence. For a distance of 1,200 miles, from the Rio Plata to Terra del Fuego, the land has been formerly raised, and in Patagonia to a height of between 300 and 400 feet. Speaking of the western coast Darwin says that "marine remains occur at intervals, and in some parts almost continuously, from lat. $45^{\circ} 35'$ to 12° S. along the shores of the Pacific. This is a distance, in a north and south line, of 2,075 geographical miles. Along this great line of coast, besides the organic remains, there are in very many parts marks of erosion, caves, ancient beaches, sand-dunes and successive terraces of gravel, all above the present level of the sea. Judging from the upraised shells alone the elevation in Chili has been 350 feet; at Conception certainly 625 feet, and by estimation 1,000 feet; at Valparaiso, 1,300 feet; at Coquimbo, 252 feet; northward of this place shells have not, I believe, been found above 300 feet; and at Lima they were falling into decay at 85 feet. Not only has this amount of elevation taken place within the period of existing mollusca and cirripedes, but their proportional numbers in the existing sea have in most cases remained the same." In Eastern Terra del Fuego the occurrences of similar terraces led Darwin to believe "that the entire breadth of the continent of Central Patagonia has been uplifted in mass."

In North America river terraces ranging in altitude from 100 to 250 feet in height above the present level of the water exist along the Missouri, Connecticut,

Hudson, Mohawk, Genesee and other rivers. These show that the producing cause was not confined solely to the coast, but was peculiar to the entire continent.

Raised beaches also occur in New Zealand. In the more northern and southern countries some of the beaches are not quite horizontal, but are found to rise in height in the direction of the poles. These facts conclusively prove that an upward and downward polar shift of the globe has occurred, and at a period of comparatively recent date.

If the terraces had been caused by a slow and gradual change of level, the uniform space between them could not have been maintained. This shows that the movements must have been instantaneous, and that the waters by which they were formed suddenly fell or were raised from one terrace to another.

Many similar instances might be cited in proof of former changes of level having taken place simultaneously throughout the entire globe, but the facts are so well known to geologists that no further confirmation is necessary. It is an old story now, worn threadbare by constant repetition in the endeavor to find its solution. But when the vast and mighty changes that have occurred in times past are seriously considered, it would be idle to account for their origin by the gradual action of the known physical agencies now in operation.

CHAPTER V.

ALLUVIAL DEPOSITS.

THE great rivers all over the globe bear unmistakable evidence of once having been gorged with a much greater volume of water than they now contain. The banks of the principal American rivers for hundreds of miles are lined with a thick coating of alluvial deposit, forming extensive lines of cliffs which rise far above the present bottoms of the valleys. It consists of a pure sediment of unstratified mud, as fine in texture as though it had been ground in a mortar, and contains the remains of land and fresh-water shells, together with traces of former vegetation. This deposit is known as loess, and is similar in character and in the nature of its vegetable and conchological genera to the loamy deposits of the basins of the Rhine and Danube, in Europe, and the Nile, in Egypt. A vast quantity of floating sediment is still being washed down by these and other large rivers, into the trunks of which it is deposited by the tributaries and streams which drain the slopes of the surrounding countries. Year after year the sediment is being carried far out into the sea, or dumped on obstructions in the course of the rivers, where the accumulations have increased to an enormous extent, contributing to

the formation of broad deltas, such as exist at the mouths of the Nile and the Mississippi.

The immense deposits of alluvial and sedimentary matter forming the delta of the latter river, in North America, are supposed by geologists to have been the accumulation of the *debris* of that river for a very extended period of time. They are many hundred feet deep, and cover an area of 25,000 or 30,000 square miles. Assuming a continual uniformity in the rate of deposition, estimates have been formed as to the length of time required for the Mississippi to discharge such a vast amount of sedimentary material, by taking into consideration the quantity of fluviatile matter carried annually in the flow of the river, which is supposed to have entirely formed the great alluvial plain or delta at its mouth. A conclusion has been arrived at that an immense lapse of ages has been necessary to allow of the formation of the delta at present existing at the entrance to the Mississippi River.

If the delta of the Mississippi had been of the same gradual formation in all time past as at present, and the quantity of sediment deposited at the present rate of accumulation, it could easily be understood why such periods of time would have been necessary for the process of formation. But there is every indication that the forces at work acted with far greater intensity in former times, for the Mississippi would require a much greater velocity than it now possesses to deposit, within a reasonable period, such an immense quantity of diluvium. A geological examination of

the country in the neighborhood of the river, near its entrance, according to Lyell, shows that the surface material rests upon an immense Drift deposit of sand and gravel, containing fragments of palæozoic rock and silicified coral, and the latter upon a lower Tertiary. In several sections of the bluff near the mouth of the river vegetable remains and stumps of erect cypress trees have been observed in the strata one above the other, corresponding exactly with the formation of the alluvial plain or delta at its mouth.

The latter bears the same geological structure as the neighboring land through which the river flows, showing that it was once a continuous portion of the mainland, and that during a change of level it has been submerged by the waters of the Gulf of Mexico. Had it not been for this obstruction the sediment now floated down would in all probability have been carried farther out into the Gulf of Mexico. At the mouth of the river there are deposits of several acres in extent, known as "mud-lumps," in which salt springs exist. An inflammable gas also rises to the surface upon them. It is highly probable that the bases of these were formed by the *debris* of the Glacial floods being deposited in submerged forests which are known to exist in the neighborhood, and the whole covered with a discharge of sediment from the mouth of the Mississippi. These saline springs, no doubt, owe their origin to beds of oceanic salt which would likely be deposited there at the time of the vertical movement which caused the change of level. The decay of submerged vegetable

matter would also form the gas which forces its way through the soft alluvium and rises to the surface.

The southern shore of the United States bears every evidence of a former submergence and elevation, and of having been eroded originally by the Gulf of Mexico. There are many peculiarities connected with the Mississippi explainable by the former changes of level, and which will be found applicable to all the large rivers in the world. Whether a river flows east, or west, or north, or south, a similar increase or decrease in its volume of water would result if a change of level took place. The Amazon, the Nile, the Ganges, the Hoang Ho, and all other great mud-carriers, have in a former time had their ups and downs in like manner, and at the same geological period as the Mississippi; and the originating causes of the one will be found to explain the geological peculiarities of all the others. In estimating the age of rivers by the deltas at their mouths a uniformity in the rate of sedimentary deposition has been generally assumed, under the impression that the physical operations now in force have been the same in all time past. But such has not been the case.

“If we could take for granted,” says Lyell, “that the relative level of land and sea had remained stationary ever since all the existing deltas began to be formed—could we assume that their growth commenced at one and the same instant when the present continents acquired their actual shape—we might understand the language of geologists who speak of ‘the epoch of

existing continents.' They endeavor to calculate the age of deltas from this imaginary fixed period; and they calculate the gain of new land upon the sea, at the mouths of rivers, as having begun everywhere simultaneously. But the more we study the history of deltas the more we become convinced *that upward and downward movements of the land and contiguous bed of the sea* have exerted, and continue to exert, an influence on the physical geography of many hydrographical basins, on a scale comparable in magnitude or importance to the amount of fluxatile deposition effected in an equal lapse of time. In the basin of the Mississippi, for example, proofs both of descending and ascending movements to a vertical amount of several hundred feet can be shown to have taken place since the existing species of land and fresh water shells lived in that region. The deltas also of the Po and Ganges have each, when probed by the artesian auger, borne testimony to a gradual subsidence of land to the extent of several hundred feet—old terrestrial surfaces, turf, peat, forest, land and 'dirt beds' having been pierced at various depths. The changes of level at the mouth of the Indus, in Cutch, and those of New Madrid, in the valley of the Mississippi, are equally instructive, as demonstrating unceasing fluctuations in the levels of those areas into which running water is transporting sediment."*

The change of level so distinctly marked in the basin of the Mississippi may be explained by a sud-

* "Principles of Geology," p. 165.

den upward shift of the North Pole. After an interval of time to allow of the accumulation of the loess, a downward polar movement would result in producing the physical peculiarities of the Mississippi, as well as the formation of the delta at its mouth, by means of the accompanying elevation and its detachment from the mainland by the force of the waters. Admitting a change in the axis of the earth's rotation as the cause of the former changes of level, and considering the enormous magnitude of the disturbing force, it will be seen that a much shorter period of time would meet the requirements of sedimentary deposition than that based on the present rate of formation. The age of the delta of the Mississippi has been estimated at from 5,000 to 70,000 years, and that of the Nile, in Egypt, at from 6,350 years upwards. But the unreliability of these figures will be seen at a glance when the former agencies which were at work are taken into account.

Along the southern coasts of Asia, and especially in India, there is distinct evidence of a great change of level having occurred during the Glacial period. In India a vast area of country is inundated with what is known as the Himalayan mud, which has been compared to the loess of Europe and America. According to Lyell, "the vast plains of Bengal are overspread with Himalayan mud, which, as we ascend the Ganges, extends inland for 1,200 miles from the sea, continuing very homogeneous on the whole, though becoming more sandy as it nears the hills. . . . To

what depth the mud extends is not known, but it resembles the loess in being generally devoid of stratification and of shells, though containing occasionally land shells in abundance, as well as calcareous concretions called *kunkur*, which may be compared to the nodules of carbonate of lime sometimes observed to form layers in the Rhenish loess. . . . Borings have been made at Calcutta, beginning not many feet above the sea level, to a depth of 300 and 400 feet. . . . At the bottom of the borings, after passing through much fine loam, beds of pebbles and boulders were reached, such as might belong to an ancient river channel; and the bones of a crocodile and the shell of a fresh-water tortoise imbedded in it were met with at the depth of 400 feet from the surface. No pebbles are now brought down within a great distance of this point, so that the country must once have had a totally different character, and may have had its valleys, hills and rivers before all was reduced to one common level by the accumulation upon it of fine Himalayan mud. If the latter were removed during a gradual re-elevation of the country many old hydrographical basins might reappear, and portions of the loam might alone remain in terraces, on the flanks of hills, or on platforms attesting the vast extent, in ancient times, of the muddy envelope.”*

Here is distinct evidence of a former change of level on this part of the globe, accompanied by a vast inundation, in which beds of gravel, sand and boul-

* “Antiquity of Man,” p. 336,

ders were deposited over the then existing surface, at a great distance from their present accumulation. An elevation of the North Pole would produce this result, for the change of level would cause a submergence of the lands on that side of the globe. Allowing an interval of time for the accumulation of the alluvium, a subsequent lowering of the North Pole would produce the existing effects, and result in the present distribution of the land and water in the East.

CHAPTER VI.

FORMER VOLCANIC EFFECTS.

WHILE the raging waters of the Glacial floods have left behind an indelible imprint of havoc and destruction, vast eruptions of volcanic matter in many parts of the globe bear testimony to the intensity of the igneous forces which accompanied them. The terrific eruptions of Vesuvius, *Ætna* and other volcanoes in modern times are feeble emissions in comparison with the immense and violent outbursts of lava, scorix and ashes that resulted from the upward and downward movements of the earth in the later Tertiary periods. Modern volcanic disturbance is characterized by rumbling subterraneous noises, accompanied with convulsive earthquakes and a discharge of vapor and molten lava, which is ejected with stupendous force many thousand feet into the air. Here the vapors spread like a broad canopy, occasionally becoming condensed and descending in a deluge of rain, ashes and mud, in such quantities as to completely inundate the surrounding country. Dark clouds of cinders and fine dust hover over the mountain top and the adjoining neighborhood for many miles, while streams of liquid lava pour down in torrents from its summit. Over this a crust is rapidly

formed by exposure, enveloping the country for miles in a shroud of complete desolation.

In Iceland, in 1783, the volcano of Skaptur Jokul alone poured out a volume of lava of not less than 655,000,000,000 cubic yards. In some places the molten material attained a thickness of over 490 feet. According to Prof. Buschoff the mass of lava poured out from the subterranean regions by this eruption surpassed in magnitude the bulk of Mount Blanc, in Switzerland. The volcano was cleft open and two great streams of fire escaped, flowing in opposite directions. One attained a length of fifty miles, with an estimated breadth of from twelve to fifteen miles; the other being about forty-five miles long and about seven miles wide. The streams attained an average height of 100 feet, but sometimes rose as high as 600 feet in the narrow defiles. A torrent of lava, in many places from 400 to 600 feet in depth and nearly 200 feet in breadth, was poured forth into the channel of the Skapta, entirely filling up the rocky gorge and overflowing the neighborhood for a considerable distance. After flowing for several days the molten lava plunged over the tremendous cataract of Stapafoss, filling up the deep gorge which had formerly been hollowed out by the fall of the water.

Previous to the eruption of Skaptur Jokul a submarine volcano burst out of the sea at a distance of 200 miles from the mainland, and ejected pumice to such an extent that the ocean was covered with that substance for a distance of 150 miles. A new island

was formed called Nyöe, from which eruptions also took place, but it disappeared again during the following year.

The eruptive nature of Vesuvius, and its destructive effects in times past, when Herculaneum, Pompeii and Stabiæ were overwhelmed, is well known. In 1872 Vesuvius poured out a molten stream of lava 3,000 feet wide and 20 feet deep, and shot forth volumes of scoriæ, fire and smoke to a height of 4,000 feet amid a roar like that of distant artillery. In Central America an eruption of Coseguina covered the neighboring country with a layer of ashes 16 feet thick for a distance of 25 miles. Ashes fell in Jamaica, 800 miles away, and the noise of the explosion was distinctly heard at Bogota, a distance of 1,025 miles. The quantity of lava emitted was not less than 65,-500,000,000 cubic yards.

The Gulf of Santorin, in the Grecian Archipelago, is known to have been the scene of volcanic eruptions for at least 2,000 years; and there is geological evidence to prove that the whole mass of Santorin formerly stood at a higher level by 1,200 feet.

Similar volcanic disturbances of equal intensity have taken place all over the globe in modern times, during which hundreds of thousands of lives have been lost, and many cities and towns entirely obliterated. If, then, such destructive results are the effect of volcanic action in the earth's natural course of events, what must have been the intensity of the igneous force and disturbance during the Drift epoch,

when the globe itself had been tilted out of position, if the shocks were the result of a sudden displacement of its axis of rotation? But there is no need to draw on the imagination for the result: the ancient lava sheets of the later Tertiary speak for themselves. This period bears the marks of two great volcanic disturbances of stupendous magnitude, in the building up of great mountain cones and the extraordinary outflow of molten lava. Along the west coast of Africa and in California the ancient lavas are spread over the country in most striking forms. In North America, during the eruptions, the neighboring river channels were filled with outflowing lava; and, as an accompanying change of level took place, the river drainage consequently became altered. The modern streams, in some instances, have cut a passage across the more ancient lava-filled river beds; and where the erosion has taken place along parallel lines, the interlying lava-topped formations are known as table mountains. In other places the rivers have excavated new channels alongside the hard lava, leaving the ancient sheets, which cover the former river bottoms, resting on elongated ridges.

With a repetition of the continental upheaval, and during the process of re-elevation, gigantic crevices and fissures were rent in the solid rock, extending perpendicularly to a great depth. Into these deep fissures rushed voluminous torrents of water, which swept through the mountains with terrific velocity, excavating and eroding the softer portions of the

surrounding rocks, and leaving those of harder composition standing in numerous peaks and isolated domes. The Grand Cañon of Colorado is a mighty gorge through a bed of solid rock 300 miles long and from 3,000 to 6,000 feet deep. The gorges of the north and south forks of the American River are rent through solid slate to a depth of from 2,000 to 3,000 feet, and others through hard granite at various depths ranging from 3,000 to 4,000 feet.

The Columbia River has found a passage through the entire Cascade range of mountains, leaving its gigantic peaks standing as the result of the erosion. The walls of the great cañons, extending for miles, are formed entirely of lava, rising to a height of from 2,500 to 3,500 feet above the surface of the river. Through fissures in the mountain range the lava poured in torrents, extending in one continuous sheet across the eastern part of Oregon to the Blue Mountains. In Sierra Nevada the flow also overspread the country to an enormous extent, building up large isolated volcanic accumulations, and forming vast lava sheets through which river channels at present exist at a depth of from 500 to 800 feet. The western coast of America, from California to British Columbia, is completely inundated with ancient lava, forming probably the largest area known. "Commencing in Middle California in separate streams," according to Laconte, "in Northern California it becomes a flood, flowing over and completely mantling the smaller inequalities, and flowing around the greater irregu-

larities of surface; while in Northern Oregon and Washington it becomes an absolutely universal flood, beneath which the whole original face of the country, with its hills and dales, mountains and valleys, lies buried several thousand feet. It covers the greater portion of Northern California and North-western Nevada, nearly the whole of Oregon, Washington and Idaho, and runs far into Montana and British Columbia on the north. Its eastern and southern limits are not well known, but its extent cannot be less than 150,000 to 200,000 square miles, with a thickness of 3,000 to 4,000 feet in its thickest part, where cut through by the Columbia river."

The magnitude of the former eruptions may be inferred from the fact that the molten lava flowed for hundreds of miles in a liquid condition, while in modern eruptions the flow generally accumulates near the vent, and seldom extends over more than a comparatively small area. Many lava eruptions take place through fissures in the mountain side; and so copious has been the flow in times past that great volcanic cones, thousands of feet in height, have been entirely built up, and owe their origin to this source alone. The great basin ranges through Utah, California and Arizona, east of the Sierra Nevada, are mainly the result of former volcanic disturbance. The great basin of the West, stretching from the Sierra Nevada to the Wasatch Mountains, at this period was a scene of tremendous volcanic action. The surface of the land and the waters of the lakes were deluged with ashes,

which, according to Newberry, were "in some instances ten or twenty feet in thickness. At other times the volcanic action was still more intense, and floods of lava were poured out which formed continuous sheets hundreds of miles in extent, penetrating far into the lake basins, and giving to their floors bottoms of solid basalt."*

In Europe many mountains and gigantic lava cones were formed, and vast basaltic eruptions took place, during the two great continental upheavals of the Tertiary period. In France the extinct volcanoes of Auvergne consist of three separate groups, and extend for a distance of 100 miles in a north and south direction, and range from 20 to 80 miles in width. The trachytic outflows are spread over an extensive area. The ancient lava streams may be traced for a distance of many miles, and in some places have filled valleys half a mile in width to a depth of 150 feet. The district surrounding the extinct volcanoes of Mont Dore, the Cantal and Mont Mezin are covered with immense beds of scoriæ and pumice, and floods of basalt.

At the foot of the Pyrenees, in the north-east of Spain, in the Appenines, in Central Italy, and in Sardinia, there are extensive groups of extinct volcanic cones of the Tertiary period. According to Judd, all through Northern and part of Western Bavaria, as well as in Central Germany, isolated hills of basalt occur by hundreds; and the volcanic district of Schemnitz, in Hungary, is a vast extinct volcanic centre,

* Hayden and Selwyn's "North America," p. 131.

covering an area of 50 miles, in which lava cones were formed in abundance. The Madeira Islands, in the Atlantic Ocean, the islands of Ascension, St. Helena, the Azores, Cape Verde and Canary Islands, were in a state of intense volcanic activity during Tertiary times. In Asia Minor, Central Asia and the Caucasus there are many remarkable groups of extinct volcanoes. In Great Britain the islands of Mull and Skye were originally parts of a vast plateau of basaltic lava nearly 2,000 feet deep, a great portion of which has been washed away by denudation. Its circumference is estimated by Judd to have been 40 miles, and its height not less than 14,500 feet.

Volcanic eruptions of a similar nature took place in India during the same geological period. Commencing on the southern line of the Vindhya and Aravulli ranges, the outflow of trap in some places attained a thickness of about 4,000 feet, covering an estimated area in Central India of 200,000 square miles.

All over the globe there is ample evidence of two eruptive outbursts of enormous magnitude, accompanied by continental changes of level, having occurred during the geological period which marks that greatest of modern terrestrial disturbances—the Glacial epoch. One of these lava sheets being more ancient than the other it is evident that an interval of time existed between each disturbance, and these were undoubtedly the result of the same cause, which produced the accompanying changes of level, viz., an upward and downward shift of the North Pole.

CHAPTER VII.

NORTH AMERICAN PRAIRIES.

“Lo! they stretch
In airy undulations, far away,
As if the ocean, in his gentlest swell,
Stood still, with all his rounded billows fixed
And motionless forever. Motionless!
They are all unchanged again. The clouds
Sweep over with their shadows, and, beneath,
The surface rolls and fluctuates to the eye;
Dark hollows seem to glide along, and chase
The sunny ridges.” — *W. C. Bryant.*

THE vast and extensive prairies of North America, and the broad and waving pampas and savannahs of the South, are remarkable features of striking admiration peculiar to the New World. Millions of acres of treeless land, covered with a rich, arable diluvial deposit, are characteristic of the whole North American continent. Far as the eye can reach appears one vast expanse of boundless meadow, to which there appears to be no terminable limit. Gently undulating, the land is sometimes rolling, and again reaches an almost unbroken level; not a tree to be seen for miles, and then only in isolated places. These plains are covered with rank and succulent grasses and plants, which attest the rich, productive nature of the soil.

The absence of trees long ago attracted attention, and many theories have been advanced as to the cause. Some have supposed the plains to have been cleared of forests by prehistoric races, while others attribute their removal to devastating fires occurring in primitive times. But with the particulars of the Drift explained there is no difficulty in understanding the origin of the treeless nature of the prairies. Over these plains the Glacial floods made a clean sweep, with a force that could not be dammed back by a wall of rock itself, rooting up trees bodily and carrying them off with the ease of a Western cyclone. The soil itself bears satisfactory evidence of having been accumulated under water. The rich, black, arable mould, several feet thick, is plainly a sediment deposited by water. In this soil fresh-water shells and other remains have been found, indicating that the land had been completely submerged. Over this inundated land vegetation soon found a foothold after the waters retreated. Grasses and flowers sprang up; the summer's heat and winter's snow of centuries contributed, with the annual decay of vegetation, to what is now a sward of rich and fertile land spread over a country abounding with animal life, and unequalled for agricultural purposes by any in the world.

Previous to the Drift the vegetation of North America was very similar to that now existing. According to Lesquereux and Newberry, oak, hickory, poplar, maple, mulberry, hornbeam, box-elder, laurel, bay, dogwood, sumac, olive, buckthorn, magnolia, smilax, white cedar, sequoia, cypress and sabal flourished,

and show the greatest affinity with species of our own time. This fact is another indication of the modern age of the Drift, and that the event occurred at a time so recent that the flora of the American continent was exactly identical with that of the present day.

The great alkali plains of the Canadian North-West and the United States deserts owe their origin to the Drift. The soil is thoroughly saturated with alkali, barren, and the water unfit for use. Here the salt water of the ocean evaporated, after strewing the contents of its basin over the surface. This formed great lakes in some places to which there was no outlet, and the water gradually evaporated, forming a crystallized deposit of salt on the bottom of the now extinct lakes. In some parts of the prairies the land is a solid bed of stiff clay, on which is deposited a layer of alkali salt three or four inches thick, with a top covering of vegetable mould. Millions of acres of land of this description are to be found in Canada alone, and the whole topography of the country may be traced to Glacial action. The great chain of North American lakes found an outlet in the St. Lawrence River, thus drawing off the salt water with which they were flooded, and contributions from the clouds promoted the maintenance of a supply of fresh water. Otherwise these lakes must have remained as inland oceans of salt water. In some portions of the country every valley, every hollow, and every depression on the surface, was filled with brine, and innumerable shallow ponds were formed from which the imprisoned waters found no escape except by evaporation. Into these

lakes the oozing mud and drainage from the hills and ridges were washed down by rains until gradually the salt disappeared beneath the mud and marl, and vegetation soon found a foothold. When the continent regained its former level the lakes gradually disappeared, leaving behind a surface of argillaceous matter and alkali, to be scorched and dried up by the heat of the sun, forming the great barren alkali plains which abound over the North American continent.

There can be no doubt that the courses of the large rivers in America, and the great chain of Canadian lakes, stretching in one long curve from the north to the south-east, owe their present peculiarities and their origin to the Drift epoch.

The indented land across the north of the whole of British America bears every appearance of having been violently torn open by the mighty icebergs of the North sweeping down the face of the continent. The broken and shattered rocky northern shores of the vast lakes, the deserts of alkali, the transported rocks and drift, show plainly the traces of violent action; while the rich valleys of the southern shores are covered by unmistakable traces of alluvial deposits, showing how destructive and widespread was the havoc caused by the flood. Here, at an elevation of from 300 to 600 feet above the sea level, nearly one-half of all the fresh water in the world is now accumulated.

The pampas of South America bear a similar geological formation as the prairies of the North, and their origin may be also traced to the same source.

CHAPTER VIII.

THE CORAL REEFS.

THE dread of mariners and the wonder and astonishment of travellers, the coral islands emerge from the waves or rise to a small depth below the surface, forming one of the most conspicuous features of the ocean. Spreading in clusters over the Pacific and Indian Oceans, they at once attract attention by the variety and beauty of their scenery and the curious nature of their structure. Rising abruptly from the bottom of the sea, some of the reefs circle round an enormous area for miles, enclosing a vast lagoon of smooth, bright green water, protected on all sides from the fury of the surging breakers by which they are surrounded. These are known as atolls. Others extend in straight lines a short distance off the shores of the mainland, or encircle smaller islands from which they are separated by a broad, smooth area of water, similar to that lying within the atolls. Externally, like the latter, they rise abruptly from the depth below, while internally they occasionally terminate in a steep perpendicular wall, or gradually slope into the lagoon.

Another class known as fringing reefs border the land shores, extending but a short distance out into the

water where the coast terminates abruptly, or spread still further as the inclination of the land extends, but only till a certain and requisite depth is attained. These three classes—the atolls, barrier reefs and fringing reefs—represent the form of the coral islands in general. On these a luxuriant tropical vegetation has obtained a foothold, and some of the choicest productions of the tropics flourish. Tall, waving coconut trees relieve the monotony of the surrounding ocean, and add materially to the habitation of the islands. Numerous birds of oceanic species, such as terns, gannets and frigate birds, find a place of abode in the islands; while turtles and other marine animals abound in the lagoons and waters of the surrounding sea, all contributing to form what are now the most conspicuous wonders of the ocean. The great Polynesian archipelago is composed almost entirely of coral islets, reef-chains and groups of atolls, forming one of the great geographical divisions of the globe. Many of these islands are of vast extent, and some of the groups spread over an enormous area. The Radick group of atolls, as described by Darwin, “is an irregular square 520 miles long and 240 broad; the Low archipelago is elliptic-formed, 840 miles in its longer, and 420 in its shorter, axis. There are other small groups and single low islands between these two archipelagos, making a linear space of ocean actually more than 4,000 miles in length, in which not one single island rises above the specified height. Again, in the Indian Ocean there is a space of ocean 1,500 miles in

length, including three archipelagos, in which every island is low and of coral formation.”*

Between New Guinea and Australia a coral formation extends for 700 miles, and on the east side of the latter are 350 miles of unbroken reefs, and a chain of reefs and islets runs on the south-west of Malabar alone 480 miles in length. The island of New Caledonia is encircled at both ends by a barrier reef 400 miles long, which extends in a continuous line beyond its northern limit for a distance of 150 miles. The reef is broken in many parts, and includes several separate and distinct rocky islands of various heights. The depth within the lagoon channel varies from 60 to 336 feet, while externally the reef rises abruptly out of the ocean. In some places the lagoon channels are very deep, ranging from 100 to 200 fathoms in depth, dividing separately what appears to have been formerly one distinct atoll. In each of the different classes of reefs similar passages form an entrance from the dashing breakers of the foaming sea without to the smooth and serene waters of the lagoons within.

The coral of which the rocky domes of the reefs are composed was formerly supposed to be a marine plant, owing to its shrub-like form, and the soft, glutinous nature of the coating with which branches are covered while in the water, but which immediately dries up and decays on exposure to the atmosphere.

In 1727 Peyssonel, a French physician, discovered that the supposed plants were minute animals, and

* “History and Geology,” p. 467.

they were afterwards designated zoophytes by Linnaeus, as indicating the twofold nature of an animal and a plant. Their general character is that of a polyp—by which they are also known—a small animal consisting of a stomach surrounded with radiating tentacles. An indefinite number of polyps may be attached together on a general frame or branch-like stalk. One of the most remarkable peculiarities connected with this class of animals is their extraordinary tenacity of life. “If a polyp be cut in two,” remarks M. Trembley, “the fore part, which contains the head and mouth and arms, lengthens itself, creeps and eats on the same day. The tail forms a new head and mouth; at the wounded end shoot forth arms; if turned inside out, the parts at once accommodate themselves to these new conditions. If the body were cut in ten pieces, every portion would become a new, perfect, living animal. A polyp has been cut lengthwise at seven in the morning, and in eight hours afterwards each part has devoured a worm as long as itself! How astonishing it is to see a creature, so apparently frail in structure, possessing the actions, sensations and powers of higher organized beings! The stomach is without membrane or cell; the outside surface cells form a kind of double skin, and the inside consists of a wall of cells running crosswise, with a velvet-like surface, being red or brown grains held together by a gluey substance.” To this class belong the corallifera, a minute tribe of wonderful character, to which the rocky domes of the coral islands owe

their formation. Living mounds of coral-builders, hundreds of miles in extent, work unceasingly in the formation of the wonderful groves and submarine forests of delicate branching corals so extensively spread over the tropical seas. Seen at work in their native element the forms and tints of the teeming millions of zoophytes shine and gleam through the clear crystal water, and present a radiant and brilliant appearance. They are described as of every shape—"some delicate and leaf-like; others with large branching stems; and others again exhibiting an assemblage of interlacing twigs of the most delicate and exquisite workmanship." Only in the water, however, do they present such an appearance, for immediately on extraction they shrivel and dry up rapidly. The soft, gelatinous body of the polyps unite the atoms of carbonate of lime from the ocean into a hard, twisted substance of symmetrical structure. By this process large masses of solid rock are formed capable of resisting the violent action of the foaming waves more firmly than if formed of granite or the hardest rock.

It has been formerly supposed that coral reefs were built from the bottom of the ocean, and that in the early stages of their operations the coral-builders worked perpendicularly, throwing up a breastwork to afford protection on the inward side from the violent action of the waters of the deep. But the latter has been found to be incorrect, for it is known that the corals growing on the exposed shore cannot live within the lagoon where the more delicate kinds exist. The

former has been also proved untrue. From observations and soundings made and confirmed it is definitely known that the greatest depth at which corals can grow is between twenty and thirty fathoms. As the coral islands are generally of a uniform height above the surface, it was clear that a foundation must have originally existed at that depth, from which the reefs were built upward. This was found to be the case, the soundings indicating that the structures were based on a bottom of sand. A generally-supposed theory was, that the atolls were based on the craters of extinct volcanoes. Though this may be undoubtedly correct respecting some of the coral islands, it is clear that they are not all of volcanic origin, for this theory has been found inapplicable for the barrier reefs, and also for the atolls when their form, size and number are taken into consideration. They appear to be based on broad, steep banks of sediment rising to a uniform height from the bottom of the ocean, and arranged in long lines for hundreds of miles, or grouped together in vast circles over an immense area of ocean. But of what origin are the bases if not volcanic? Are there any similar structures known to exist that a comparison might be made with in order to obtain an idea as to their formation? Yes; the osars and the great ridges and reefs of the Drift epoch. During the Post-glacial period a submergence of the ridges and reefs took place with the accompanying changes of level, while the corals again grew upward to the surface. If these facts are considered it will be seen that the coral

reefs are of comparatively modern origin ; and that instead of requiring an "immense series of ages" for their formation, two or three thousand years under such circumstances would suffice for the present growth of the coral islands. It has been estimated that the rate of growth of the common madrepore, one of the most abundant of the coral tribes, is not over an inch and a half a year. After making allowance for porosity, disintegration and other reducing causes, and computing the thickness of some of the coral reefs at about 2,000 feet, the result arrived at has been one of those "inconceivably vast periods of time" which have never had an existence except in the imagination ! If the corals grew from the bottom of the ocean, at their known rate of increase, there might be some truth in such a result ; but it is well known that corals live only in comparatively shallow water, and that the greatest depth at which they can exist is from 120 to 180 feet. It is also well known that a foundation of some sort exists on which the structures are based.

From the top of their bases to the surface of the water the coral builders work, and the existence of ancient beds of dead coral on many of the islands is an indication that they formerly existed near the surface. These were afterward deprived of life by submergence in deep water during the universal change of level which accompanied the Post-glacial period.

CHAPTER IX.

THE FAUNA OF THE TERTIARY PERIOD.

IN Geology the Tertiary formation is that which follows the close of the Cretaceous period and extends upward to the Boulder formation of the Drift epoch. It has been divided into three divisions by geologists, and these again sub-divided, but the principal ones now generally followed are those named by Lyell as Eocene, Miocene and Pliocene. These with their subdivisions, form what is known as the Tertiary formation. The Tertiary period is described as the "reign of mammals." The gigantic extinct animals—the mastodon, mammoth, and other great pachyderms and ruminants—then roamed over the greater portions of the Old and New Worlds in herds; while South America was the home of colossal edentate giants, such as the megatherium and mylodon. In Europe the elephant, rhinoceros, hippopotamus, tiger, hyena, bear, wolf, ox, camel, deer and smaller animals, abounded from the Mediterranean to the Arctic Ocean. The animal remains of this geological period are found, in some cases in great quantities, buried in ancient marshes and alluvium, in caves, or frozen and embedded in arctic ice. The mammoth (*Elephas primigenus*) far surpassed in size the

largest elephant of the present time. It stood nearly a third taller, being from fifteen to sixteen feet in height, with a body nearly thirty feet in circumference. It was covered with long, bristly hair, while a rough, shaggy mane hung from its neck and extended along its back. Underneath was a woolly coating of fine hair four or five inches long. The tusks of this animal weighed from 150 to 200 pounds, and are eagerly sought for as fossil ivory. In one year alone—1844—16,000 pounds were sold in St. Petersburg. Two enormous truncated tusks projected forward from the head, curving outward and backward. Its teeth were massive structures, measuring as much as a foot and a half in length, and weighing about seventeen pounds each. The grinding teeth were of a peculiar nature, the crown being divided into a number of plates ranging in succession, and these plates again into a sub-cylindrical process, resembling a perfect tooth, each being complete within itself, the growth of the whole being of a gradual formation, as required by the animal.

In the museum of St. Petersburg a perfect skeleton stands as high as sixteen feet. The tusks measure one foot across the base, and fourteen feet long. The sole of the foot alone is a yard in diameter. Several discoveries of perfect specimens found have been described. At the beginning of this century, Adams, a Russian naturalist, discovered the carcass of a mammoth at the mouth of the River Lena, in Siberia, frozen and completely enveloped in ice. It retained

all its parts, and was so perfectly preserved that, when thawed, its flesh was devoured by dogs. Since that time many similar discoveries have been made, from which the nature and the habits of the animal were gleaned, and are now well known. In 1843 Midden-dorf found a mammoth in such a perfect condition that the bulb of the eye is still preserved and on exhibition at the museum in Moscow. Several other instances are known of complete specimens being found embedded in frozen ice.

The mammoth roamed over the greater part of the earth—in North America from the Arctic regions to the Gulf of Mexico, and in the eastern hemisphere from Siberia to the West of Europe as far south as the Mediterranean. The bones of these animals, together with those of the elephant and rhinoceros, have been found in thousands in Siberia, “heaps upon heaps,” where they are extensively sought for the sake of their tusks, of which an enormous quantity has been found and sold. The remains of elephants are found in such abundance in Northern Russia and Siberia that the statements of travellers made concerning them appear almost incredible. Whole islands, many miles in length, are described as being formed almost entirely of the bones of these animals. New Siberia and the Lāchow islands, off the mouth of the River Lena, are of this nature, forming an actual ivory quarry from which a constant supply has been exported to China for five hundred years, and Europe for the last ‘century, with apparently no signs of exhaustion.

“There is not,” says Pallas, “in all Asiatic Russia, from the Don to the extremity of the promontory of Tchutchis, a stream or river, especially of those which flow in the plains, on the banks of which some bones of elephants and other animals foreign to the climate have not been found. But in the more elevated regions, the primitive and schistose chains, they are wanting, as are marine petrifications. But in the lower slopes and in the great muddy and sandy plains, and above all, in places which are swept by rivers and brooks, they are always found, which proves that we should not the less find them throughout the whole extent of the country if we had the same means of searching for them.”

The mastodon (*giganteus*) equalled the elephant in height, but its limbs were thicker and the abdomen slighter and of greater length. The head was also larger and more massive. Its tusks were four in number, the two upper ones curving upward to a length of twelve or fourteen feet. Two tusks also appeared in the lower jaw, one only in the adult male reaching development, both being shed early in the female. The name “mastodon” was given by Cuvier, who designated it such from the nature of its teeth, *mastos* being the Greek for nipple, and *odons* a tooth, or nipple tooth. The tooth is of a rectangular form, the surface of the crown being formed of great conical tuberosities with rounded points ranged in pairs, to the number of four or five; and from remains of undigested food in its stomach, and other evidence, it

is clear that it subsisted chiefly on vegetation, such as the tender branches of trees and leaves. The teeth bear no resemblance to those of the carnivora, but partake of the nature of those of the hippopotamus and other herbivorous animals. The animal roamed over a vast extent, from the tropics, both north and south, into the temperate latitudes, its bones being found in vast quantities throughout North America.

Among the most remarkable of the Tertiary mammals was the gigantic *dinotherium*, which was even superior in dimensions to those of the mastodon or the mammoth. It is believed to have inhabited the great swamps bordering on the banks of rivers and the fresh-water lakes. Its lower jaw was armed with defensive tusks, curving downward, which appear to have been formed for the purpose of tearing up from the bed of the river or lake the roots of aquatic plants, for which the large surface of its teeth and the powerful muscles of its jaws were apparently adapted. It possessed a long tapir-like proboscis, which it evidently employed in gathering the plants that floated on the surface or the leaves of trees which hung suspended over the waters. In 1837 a nearly perfect head of one of these animals, found at Eppelsheim, in the Grand Duchy of Hesse-Darmstadt, was publicly exposed on exhibition in Paris. It was nearly a yard and a half long, and over a yard wide. The molar teeth were analogous to those of the tapir, while its enormous tusks were curved inwards, being carried at the anterior extremity of the lower maxillary bone. Two

great holes joined to the nasal bone, under the orbits, indicated the existence of a trunk or proboscis.

The rhinoceros abounded in great numbers during the Pliocene period. The rhinoceros (*tichorinus*) was remarkable for the peculiar formation of its nostrils, which were separated in two by a bony partition, a peculiarity which bears resemblance to that of the existing species. The nose of this animal was surmounted by two horns, of a much larger size than those carried by such animals of the present day, while its body was clothed with skin covered with very thick hair. Several other species existed, among them a dwarf, in size resembling the common hog.

Pallas gives an interesting account of the discovery of a rhinoceros (*tichorinus*), which had been taken out of the ice in a remarkable state of preservation. It was found on the banks of the Viloui River, near a low, sandy hill about a hundred feet high. "The body of the rhinoceros," he says, "had been buried in coarse gravelly sand near this hill, and the nature of the soil, which is always frozen, preserved it. The soil near the Viloui never thaws to the depth of two yards in the more elevated sandy places; in the valleys, where the soil is half sand and half clay, it remains frozen at the end of summer half an ell below the surface. Without this intense cold the skin of the animal and many parts of it would long since have perished. The animal could only have been transported from some southern country to the frozen north at the epoch of the Deluge, for the most ancient chronicles speak of

no change of the globe more recent to which we could attribute the deposits of these remains and of the bones of elephants which are found dispersed all over Siberia."

Commenting on the extensive range of these animals Figuier remarks: "It is very strange that the East Indies, that is one of the only two regions which is now the home of the elephant, should be the only country in which the fossil bones of these animals have not been discovered. In short, from the preceding enumeration it appears that during the geological period whose history we are recording the gigantic mammoth inhabited most regions of the globe. Nowadays the only climates which are suited for the existing race of elephants are those of Africa and India, that is to say, tropical countries; from which we must draw the conclusions to which so many other inferences lead, that, at the epoch in which these animals lived, the temperature of the earth was much higher than in our days; or more probably, the extinct race of elephants must have been adapted for living in a colder climate than that which they now require."*

In Great Britain the hippopotamus found a home in the rivers and lakes, while wild oxen, gigantic elks, and other animals of proportionate dimensions and strength, tenanted the forests and plains. The huge carnivorous animals, such as the lion, hyena, tiger, bear, wolf, leopard, lynx and wild cat, larger and more ferocious than those of the present time, skulked in

* "The World before the Deluge," p. 350.

the forests, and made them an uncomfortable habitation for their weaker neighbors.

Among the animals inhabiting South America the megatherium occupied a place between the sloths and the ant-eaters, burrowing in the soil like the latter animal, and subsisting on the leaves of trees like the former. In size it exceeded the largest rhinoceros. Its ponderous bones show the animal to have been of colossal dimensions. As represented by Hawkins, the skull is two feet nine inches in length and one foot six inches in breadth. The head was relatively small in proportion to the body, and evidently possessed a snout analogous to that of the tapir. Its molar teeth resemble those of the elephant, their structure indicating that the animal was not carnivorous. In dimensions it was about eighteen feet in length and eight feet in height, with a body like that of an elephant. The pelvis was of enormous size, the massive iliac bones being nearly at right angles with the vertebral column, and the distance from their external edges being over a yard and a half. The femur, or thigh bone, was three times as thick as that of an elephant, being twenty-six inches in circumference. The leg bones were short and very thick. The forearms terminated in hands about a yard long and one foot broad, and were furnished with long and powerful claws, or talons, evidently designed for excavating the earth and penetrating to the roots of vegetables and other plants on which the animal subsisted. The whole anatomical organization indicates slow, pon-

derous and powerful locomotion, its massive dimensions denoting its movements to have been excessively slow, hardly able to drag itself along, but making up for lack of agility in its incalculable strength. The huge tail, which is supposed to have been used as a support when the animal raised upward, was six feet in circumference at the base. As the dimensions of the animal were too ponderous to enable it to climb a tree to obtain the foliage in the manner of the sloths of the present day, it is represented as leaning against the trunk of a tree in a semi-erect attitude, the huge tail forming a tripod to support the heavy carcass, while the unwieldy arms gathered in the vegetation on which it subsisted.

The megalonyx was another genus of sloth-like animals, and so named in allusion to the wonderful size of its claws.

The scelidotherium was a similar animal to the megalonyx, being as large as a rhinoceros, and also found in South America.

Another genus, known as the mylodon, measured eleven feet in length, and was larger than an ox. It belonged exclusively to South America, and differed from the megatherium in the structure of its teeth, the molars presenting a smooth surface, indicating that the animal existed on leaves, tender buds and vegetables. It is supposed to have formed a link between the ungulated, or hoofed, animals and the edentata, from the fact that it presented both hoofs and claws on each foot.

"The habits of these megatheroid animals," says Darwin, "were a complete puzzle to naturalists until Prof. Owen, with remarkable ingenuity, solved the problem. The teeth indicate that they lived on vegetable food, and probably on the leaves and small twigs of trees. Their ponderous forms and curved claws seem so little adapted for locomotion that some naturalists have actually believed that, like the sloths, to which they are intimately related, they subsisted by climbing, back downwards, on trees, and feeding on the leaves. It was a bold, not to say preposterous, idea to conceive even antedeluvian trees with branches strong enough to bear animals as large as elephants. Prof. Owen, with far more probability, believes that instead of climbing on the trees they pulled the branches down to them, and tore the smaller trees up by the roots, and so fed on their leaves. The colossal breadth and weight of their hinder quarters, which can hardly be imagined without being seen, become, on this view, of obvious service instead of being an incumbrance; their apparent clumsiness disappears. With their great tails and huge heels firmly fixed like a tripod in the ground they could freely exert the full force of their long, powerful arms and great claws. The mylodon was furnished with a long, extensile tongue, like that of the giraffe, which by one of those beautiful provisions of nature thus reaches its leafy food."

The glyptodon was a gigantic South American armadillo, with a mail-clad covering resembling the

shell of a turtle. This animal was enveloped in a solid tessellated carapace, being covered on the upper surface from head to tail by a hard, scaly shell formed of numerous segments. Each jaw was armed with sixteen teeth, possessing ten broad and deep grooves, dividing the surface of its molars into three parts. The feet were evidently formed for supporting a great, heavy carcass, while the phalanges were armed with short, thick and powerful claws. Some of these mail-clad species were as large as a rhinoceros or a North American bison.

In the gypsum of Paris, of the Eocene period, the remains of other pachyderms have been found of a very curious nature. The *adapsis* was apparently a gigantic hedgehog three times the size of the species now existing, and appears to have formed a connecting link between the insectivorous carnivora and the pachyderms.

The *palæotherium* was a three-hoofed animal as large as a horse, and resembling a tapir in form.

The *anoplotherium* was an animal about the size of an ass, the feet terminating in two large toes, the tarsus of which resembled those of a dromedary. They formed an equally-divided hoof like that of an ox or other ruminant. It possessed a tail of about a yard long and very thick at the base, which probably served as a rudder when swimming in water, which it frequented in search of roots and stems of aquatic plants, it being a strictly herbivorous animal. "Judging from its habits," says Cuvier, "the *anoplotherium* would

have the hair smooth like the otter; perhaps its skin was even half naked. It is not likely, either, that it had long ears, which would be inconvenient in its aquatic kind of life; and I am inclined to think that, in this respect, it resembled the hippopotamus and other quadrupeds which frequent the water much."

In Central Europe the auroch, the bison and the reindeer roamed over the plains, and the brown bear, wolf, dog, wild boar, goat, sheep, fox and badger existed in great numbers.

One of the largest and most curious of ruminants was the *sivatherium*, the remains of which have been found in the Sewalik Hills, one of the spurs of the Himalaya Mountains in India. It derives its name from the Indian deity, *Siva*. The animal appeared to have been a gigantic deer, rivalling the existing elk in size and dimensions. The head carried two pair of horns, one pair projecting forward above the eyes, and the other, lesser in size, spreading in broad tines above the forehead.

Ireland was the home of a gigantic elk, known as the *megaceros hibernicus*, that ranged from that country as far as Italy.

The wild goat, chamois, musk-ox and marmot abounded in France and Spain; beaver were common in the rivers and lakes of Europe; and numerous other smaller animals of still existing species were everywhere to be found.

In the Miocene period the apes are found. The *mesopithecus*, of which an entire skeleton was found

by M. Albert Gaudry, at Pikermi, in Greece, resembled a dog-faced baboon, while remains of other species have been discovered, but only in an imperfect condition.

A great number of reptiles existed during the Tertiary period. In America the remains of the *zeuglodon*, a great alligator-like animal allied to the whale, are found over the cotton lands of the Southern States. This animal had a head six feet long, its immense jaws being armed with a row of formidable teeth. Its length was about seventy feet.

The gigantic amphibious batrachian, known as the salamander, lived during this period. It attained the dimensions of a crocodile.

All the foregoing animals are now extinct, and various reasons have been assigned for their extinction; but the floods of the Drift epoch will be found correctly to explain the cause.

In America the remains of the mastodon and elephant are mostly found in superficial deposits, in the bogs, swamps and shell-marl of lakelets and ponds, and in the river-gravel deposits. Some have been found in an erect position near the surface, as though they had but sunk in the bog. As these ancient lakelets, bogs and sedimentary accumulations owe their origin to the Drift, it is not difficult to see why these gigantic animals are now extinct. In these cases it would be an utter impossibility to assign to these bones a remote antiquity such as that variously ascribed to them. It would be hardly credible to suppose for a

moment that these remains could have resisted disintegration, under unfavorable circumstances, for 5,000 years, much less a period of 100,000 or 200,000 years. In the case of the mammoth, where the animal was completely encased in frozen ice, the remains would undoubtedly be preserved for ages; but the mammoth and the mastodon were contemporary, and both became extinct simultaneously. There is the clearest proof that these animals perished suddenly. In Siberia the remains are found in a vast assemblage, showing that the animals sought a place of safety; while the trees of that geological period have been uprooted and blown down, presenting every trace of disorder and violence.

Lyell quotes a letter to Baron Humboldt from Prof. Brandt, of St. Petersburg, giving particulars of the carcass of a rhinoceros obtained from Wiljuiskoi, in latitude 64° , from the banks of the Wiljui, a tributary of the Lena, by Pallas, in 1772: "I have been so fortunate as to extract from cavities in the molar teeth of the Wiljui rhinoceros a small quantity of its half-chewed food, among which fragments of pine leaves, one-half of the seed of a polygonaceous plant, and very minute portions of wood with porous cells (or small fragments of coniferous wood), were still recognizable. It was also remarkable, on a close investigation of the head, that the blood vessels discovered in the interior of the mass appeared filled, even to the capillary vessels, with a brown mass (coagulated blood),

which in many places still showed the red color of blood."*

The foregoing is a sure indication that the animal had been feeding just previous to its death when overtaken by the Post-glacial flood that rooted and tore up the trees, and swept the vast mammalian herds out of existence before they had any time to prepare for escape. In this manner perished all the gigantic mammals and nearly all the other strange animals of the Tertiary period which are now totally extinct. The deluge by which they were suddenly overtaken can be accounted for by a sudden downward shift of the North Pole from a vertical position. During the Inter-glacial period, subsequent to an upward movement, the axis of the earth would occupy a position perpendicular to the plane of the ecliptic, resulting in a perpetual equinox. The Arctic region would then become open and habitable. In these high latitudes many of the great mammals of the Tertiary period roamed in thousands until a sudden downward movement of the North Pole brought upon them the waters of the Arctic Ocean, by which they were forever blotted out of existence.

* "Principles of Geology," Vol. I., p. 183.

CHAPTER X.

CAVE DEPOSITS.

THE bone caves of Europe and America, which have been found to contain human and animal remains, are supposed by many to have formed the habitations of men or animals in primitive times, and are referred to as evidence of the great antiquity of man. They are mainly extensive, natural rocky cavities of various size and irregular form, generally situated at some height above the level of the present watercourses, and communicating with the open air by fissures in the roof or ancient channels in the mountain side, through which a stream of water originally flowed. When first discovered these openings have been found choked up with detritus, and the caverns and their contents hermetically sealed. These were found to contain bones of extinct species of the bear, lion, rhinoceros, elephant, tiger, hyena, and other species still existent, together with human remains and implements of flint and stone, buried pell-mell in a mass of dark sandy sediment at the bottom of the caves. The remains are generally covered with a thick layer of stalagmite, on the top of which rests a thin layer of surface soil, of which the floors of the caves are formed. Very rarely has the complete re-

mains of any animal been disinterred, all found being fragments, detached and scattered over the floors of the caves. The bones of some of these animals have been found broken and cracked, rounded and polished, while others are in perfect condition, bearing no marks of violence whatever. Dispersed through the cave-mud have been found many species of land shells, mingled with bones of birds, and occasionally fish, etc. Comparatively few of these caves have been discovered containing human bones.

Out of eight hundred Brazilian caves examined by Lund, only six contained human remains. Of forty-eight Belgian caves explored by Schmerling, in two or three only were human bones found. Still there are several instances where they have been discovered, and sufficient evidence has been obtained to prove beyond all doubt that man existed contemporaneously with the animals whose remains are found in the caves.

The most remarkable of these bone-caverns are those of Gailenreuth, near Liège, in Germany; those of Britain—in Devonshire, Somersetshire, Derbyshire and Yorkshire; others in France; and those of Kentucky and Virginia, in America. Bone caves have been discovered in Australia of a similar nature to those of Europe and America, containing cemented fragments of bones of animals common to the same geological period.

Many of these caves, containing the remains of man and his industry, together with the bones of extinct

species of animals, have been discovered throughout Europe. Among them is the celebrated cave known as Kent's Hole, in Devonshire, England. The principal cavern is about 600 feet long, into which emerge many fissures or crevices in the surrounding rock from all directions. The floor of the cave, which was formed of a red sandy clay, was found strewn with a vast assemblage of bones of extinct and existing animals, such as the mammoth, bear, lion, rhinoceros, hyena, reindeer, Irish elk, beaver, etc., together with numerous flint and bone implements. The whole mass was covered by a thick bed of ancient stalagmite, on which rested a thin layer of surface soil. This cavern presented undoubted evidence of having been at a former period submerged under water, from which it afterwards emerged, and remained entirely closed till the day of its discovery.

The celebrated cave at Brixham, opposite to the Bay of Torquay, was composed of several passages, with four entrances which were blocked up with breccia and other material. The main opening of the cave was found to be 78 feet above the valley and 95 feet above the sea level, the opening being eight feet wide. The contents were found to consist of the bones of elephants, rhinoceros, bears, hyenas, lions, reindeer, horses, oxen, and rats and other rodents. No human remains were found, but many flint knives and other implements. These lay on a bed of gravel and pebbles in which no remains were found, while a layer of reddish loam from two to thirteen feet thick, containing pebbles and angular stones, overlaid the remains, the whole

being covered with a layer of stalagmite from one to fifteen inches thick. The entire hind leg of a bear was found among the remains, which could only have been introduced when clothed in its flesh. The cave presented no appearance of ever having been inhabited by man or any other animal. The erosive action of the water on its walls could be distinctly traced, and at the time of its formation, as shown by a report made by Mr. Bristow to the Royal Society, the land was at a lower level to the extent of 95 feet, and that its mouth must have been then situated at or near the level of the sea.

From the south of France many discoveries of these ossiferous caves have been reported, containing a similar association of remains; and buried in the alluvium and gravel beds in the valley of the Somme human remains were found in company with the bones of extinct animals. Further discoveries in other places have resulted in the finding of arrow heads, flints, hatchets and other implements of stone, together with the crania of man and the bones of other animals.

Many conjectures have been advanced as to the cause of such an assemblage. By some the caves are supposed to have been the habitations of man, owing to the presence of rude implements, flint arrow and spear heads, mingled with human bones, found in the caves. Others are of opinion that these caverns were sought formerly as places of refuge by animals broken down with old age, and compelled by instinct to seek a place of safety; that they were afterwards inhabited

by a succession of human beings and animals, and that floods of running water may have displaced the remains and mingled them in the confused mass in which they have been found.

Cuvier and the earlier geologists were of opinion that these ancient animals were destroyed in some terrible catastrophe, and that they had been engulfed during a great inundation; but this idea is now generally abandoned by modern scientists, who assign their extinction to local causes of a slow, successive nature, and principally to a gradual lowering of the temperature, and for other natural reasons generally. Nearly all these bone caves have been found imbedded in the old channels of former rivers which have long since disappeared, and generally covered by a deposit of broken gravel and sand of the Boulder formation of the Drift epoch. They are not artificial caves hewn out of the rock, and bear no traces of mechanical excavation whatever, but are simply hollow cavities, consisting of numerous chambers, connecting with each other by long and narrow passages. Occasionally some are found several miles in length. The interior walls generally present traces of the erosive action of water, and the floors are covered with a thick coating of the calcareous deposit called stalagmite. This is a deposition of carbonate of lime, formed by infiltrating water through the overlying limestone dripping into the interior of the cavern. As recorded in Lyell's "Antiquity of Man," Liebig gives an instance, and thus describes its formation: "On the surface of Franconia,

where the limestone abounds in caverns, is a fertile soil in which vegetable matter is continually decaying. This humus being acted on by moisture and air evolves carbonic acid, which is dissolved by rain. The rain-water thus impregnated permeates the porous limestone, dissolves a portion of it, and afterwards, when the excess of carbonic acid evaporates in the caverns, parts with the calcareous matter and forms stalactite. So long as water flows, even occasionally, through a suite of caverns, no layer of pure stalagmite can be produced; hence the formation of such a layer is generally an event posterior in date to the cessation of all system of drainage, an event which might be brought about by an earthquake causing new fissures, or by the river wearing its way down to a lower level, and thenceforth running in a new channel. All of the caves are connected with the surface of the earth by narrow, oblique, or almost upright crevices choked up with soil and gravel; and in some places the rents communicating with the surface are filled to the brim with rounded or half-rounded stones, angular pieces of limestone and shale, besides sand and mud, together with bones, chiefly of the cave-bear."*

It is a very prevalent and universal belief that these and other caves formed the habitations of primitive man; but with the exception of a few isolated cases there is no ground whatever for such a supposition. Man and the animals could not inhabit the caves simultaneously. The presence of flint arrow heads

* Lyell's "Antiquity of Man."

and implements show clearly that man in those days knew how to protect and defend himself against wild beasts. But the bones of both are found in the caves in a broken and confused heap, showing that none escaped, but all shared the same fate alike. If man inhabited the caves previously to the animals, traces of habitation around the walls or on the floor should be found; but the caves are natural cavities in the rock, and show no signs of artifice whatever. These scattered and confused bones, their rounded and polished condition, the grooved and scratched appearance of the walls, the broken gravel and drift, and the dripping stalactite, all point to the one and only conclusion—they were caught suddenly in the first dreadful cataclysm of the Drift epoch, caused by a sudden elevation of the North Pole, and escaped trituration through being sucked into the caverns by the vortex of waters above. Here they were whirled round and round against the walls of the caves until the waters subsided, when they were torn to pieces and fell to the floor in the confused position in which they are now found. After the waters flowed out of the cave the dripping from the stalactite roof formed the thick bed of stalagmite which covered the remains for centuries and preserved them in the confused condition in which they now lie.

Such a conglomerated mixture of gravel, mud, pebbles, shells, flint arrow heads, with an immense quantity of bones of animals of different species, could have only been borne thither by the waters of a flood.

This has been objected to on the ground that often the most fragile and delicate bones present no trace of having been carried in a current, and their acute edges and perfect condition show no trace of violence whatever. But this objection is easily explained by supposing the animals to have been carried thither bodily in the flesh, or torn to pieces, as undoubtedly they must have been, when the tremendous nature of the Glacial floods is taken into consideration. There is absolute proof that such was the case. In the sediment of Dream Cave, in Derbyshire, England, an almost entire skeleton of a rhinoceros was found, which is sufficient evidence to show that the animal must have been clothed with flesh when introduced into the cavern. There are a great many technical objections raised, also, against the filling of these caves in this manner; but this will be found to be the only solution, not only of the presence of the bones, but of the formation of the caves in which they have been found. Louis Figuier held this opinion: "The bones most frequently found in caves," he says, "are those of the carnivora of the Quaternary epoch, the bear, the hyena, the lion and tiger. The animals of the plain, and notably the great pachyderms—the mammoth and rhinoceros—are only very rarely met with, and always in small numbers. From the cavern of Gailenreuth (Franconia) more than a thousand skeletons have been taken, of which eight hundred belonged to the large *ursus spelæus*, and sixty to the smaller species, with two hundred hyenas, wolves, lions and gluttons. In the Kirkdale

cave the remains . . . included about 300 hyenas of all ages. Dr. Buckland concludes from these circumstances that the hyenas alone made this their den, and that the bones of other animals accumulated there had been carried thither by them as their prey. It is, however, now admitted that this part of the English geologist's conclusions do not apply generally. In the greater number of caves the bones of the mammals are broken and rubbed as with a long transport—*rolled*, according to the geological expression—and finally cemented by the same mud, and surrounded by the rocks of the neighborhood. Besides bones of hyenas are found, not only the bones of inoffensive herbivora, but the remains of lions and bears. All these circumstances unite in establishing that the bones which fill the caverns have been floated at random into these cavities by the rapid current of the diluvial waves. The bone-caves are generally found near the entrance of the valley, in the plain, or at a height which exceeds the limits of the diluvial phenomena. We may then suppose that, in the greater number of caves, the animals, surprised and killed by the sudden and impetuous torrents, have been drawn into the caves by the currents, where they have been engulfed, and cave and bones buried in the diluvial mud.”*

As an argument in favor of a great antiquity for these ossiferous caves it is held that the formation of stalagmite is a process so slow that thousands of centuries must have elapsed in order to allow of the

* “The World before the Deluge,” p. 376.

accumulation of a bed of that deposit one foot in thickness. If it could be shown that the operations now in force have been the same in all time past, this objection might be considered sound. But the great changes of level which occurred during the Glacial period must be taken into account, and allowance made for the stupendous effects of these terrestrial disturbances. In the "Epoch of the Mammoth" Southall cites several authentic instances in which stalagmitic matter has accumulated with considerable rapidity. In one of the Gibraltar caves two swords and a copper plate were found. The latter, on which the figure of a dragon was enamelled, lay beneath eighteen inches of hard stalagmite, and this covered by six feet of earth. The date at which they were used is known to have been about the end of the twelfth century.

"Recent facts show," says Sir William Dawson, "that under favorable circumstances stalagmite may be deposited in a much shorter time than hitherto supposed . . . In Kent's cavern the thin film of carbonate of lime which has formed over dates scratched on the rock more than two centuries ago, would lead to the belief that the thick beds of stalagmite in that cave would require even half a million years for their formation; but observations in other caverns show that under favorable circumstances beds of this thickness might be formed in a thousand years."*

At all events, the condition under which the stalagmite was formed were altogether different from those

* "Fossil Men," pp. 222, 244,

now existing, and the formative process must have acted with greater intensity than at the present time. The caves are now elevated far beyond their former level, and depend mainly on rainwater and such minor percolations for the accumulation of stalagmite where its formation has not already ceased. Previously they were constantly exposed to the dripping action of the surrounding river-beds to which many of the caves were then contiguous, as well as aided by the dissolving power of acidulated water, generated during an accompanying movement of elevation. In the Brixham cave, for instance, it has been shown that at the time of its formation the land stood at a lower level to the extent of ninety-five feet, its mouth being then situated near the level of the sea. Under such conditions the formation of stalagmite must have undoubtedly proceeded with far greater rapidity than at the present time under less favorable circumstances; and there is no just grounds whatever for assuming the process to have occupied a period extending over hundreds of thousands of years. "In any case," says Sir William Dawson, "to apply to the explanation of such cases the continued operations of merely modern causes, without taking into account floods and other cataclysmic agents, is a stretch of uniformitarianism which the deposits in the caves themselves plainly contradict."*

Isolated cases are known where men have discovered caves of a habitable nature, and temporarily made

* "Fossil Men," p. 224.

them a place of abode. Such, apparently, was the cave of Chaleux, in Belgium, where 30,000 flints were found, together with numerous carvings and engravings on bone, ivory, stone, etc. The remains of a hearth formed of flat stones, and containing a quantity of coals and ashes, lay in the centre of the cave, indicating temporary habitation. But that man generally inhabited those caves as a semi-savage, hundreds of thousands of years ago, and afterwards gradually emerged in civilization, there is no substantial evidence whatever. The skilful engraving and other artistic work found in the caves testify to the contrary, both in manner of delineation and their remarkable state of preservation. Southall cites as an example an engraving on bone of a browsing reindeer, found in the grotto of Thäyngen, in Switzerland, of which he says: "The drawing, so elegant and accurate in its execution, speaks louder than all the facts presented to prove the antiquity of man. No imbecile hand guided that pencil, and the blood which coursed in its veins is not separated by any extravagant period from the blood which produces the same artistic representations to-day."*

In addition to the remains of man and animals found in the caves, primitive works of art and industry are found in abundance throughout the continent of Europe, nearly all of which appear to have had an abrupt termination. These include the megalithic monuments and tumuli, which are found in abun-

* "Epoch of the Mammoth," p. 70.

dance throughout the western hemisphere, and also the ancient lake dwellings of Switzerland. Not only do the ossiferous caverns owe their contents to the Drift, but nearly all the fossil beds of the same geological period, such as the Danish peat mosses, with their ancient submerged forests, and others which have borne investigation and were found to contain similar remains, can be ascribed to the same cause.

The great geological peculiarity connected with the peat bogs of Denmark is the fact that the forests consist mainly of species of trees which formerly grew in abundance, but have long since disappeared, and still refuse to thrive when afterwards re-introduced. This will be found explainable by the change of climate by which the Drift epoch was accompanied.

CHAPTER XI.

HISTORICAL RECORDS OF THE DRIFT.

THAT such disastrous events as the Glacial floods could have occurred since the existence of man upon the globe, and at times when civilization was comparatively far advanced, would seem an almost unaccountable fact if no authentic records of the same had not been preserved. But it is well known that many nations have traditionary evidence of a deluge, or even more than one, in which, with a few exceptions, their ancestors were swept away and the world destroyed. As most of these nations were idolaters it is but natural that they should ascribe the origin of the floods to their gods. In this form the various accounts have been preserved and handed down in a combination known as mythology. By sifting the real from the imaginary, in many instances the authentic facts may be obtained. These traditionary evidences of great floods have been almost universally supposed to refer to the occasion and principal events connected with the Noachian Deluge, as described by Moses in the Book of Genesis. But such is not generally the case, and a careful investigation will show that the majority of these traditions are direct and reliable accounts of the floods of the Glacial epochs.

The Chinese historical records contain accounts of a great flood which occurred in the reign of the Emperor Yâu, or Yêo, to whom is credited the merit of having successfully combatted the ravages of the flood, and of repairing the damage occasioned by the inundation.

According to Sir William Jones, it is recorded by the Chinese that "the pillars of heaven were broken; the heavens sunk lower towards the north; the sun, the moon and the stars changed their motions; the earth fell to pieces, and the waters enclosed within its bosom burst forth with violence and overflowed it. Man having rebelled against heaven, the system of the universe was totally disordered. The sun was eclipsed, the planets altered their courses, and the grand harmony of nature was disturbed."*

The event is thus recorded in the Shû King, one of the Sacred Books of the East:—

"Yêo, in what year of his reign we are not told, appears suddenly startled by the ravages of a terrible inundation. The waters were overtopping the hills and threatening the heavens in their surging fury. The people everywhere were groaning and murmuring. Was there a man capable to whom he could assign the correction of the calamity? All the nobles recommended one Khwăn, to whom Yêo, against his own better judgment, delegates the difficult task, on which Khwăn labors without success for nine years. His son, Yü, then entered on the work. From beyond the western bounds of the present China

* Discourse on the Chinese, "Asiatic Resources," Vol. II., p. 376.

proper he is represented as tracking the great rivers, here burning the woods, hewing the rocks and cutting through the mountains that obstructed their progress, and there deepening their channels until the waters flow peacefully into the Eastern sea. He forms lakes and raises mighty embankments, till at length the grounds along the rivers were everywhere made habitable, the hills cleared of the superfluous wood, and access to the capital was secured for all within the four seas. A great order was affected in the six magazines (of material wealth); the different parts of the country were subjected to an exact comparison, so that contribution of revenue could be carefully adjusted according to their resources. The fields were all classified according to the three characters of the soil, and the revenues of the Middle Kingdom were established. Of the devotion with which Yü pursued his work he says himself, in the 'Yî and Kî': 'I deepened the channels and canals, and conducted them to the streams, at the same time, along with Kî, sowing grain, and showing the people how to procure the food of toil in addition to flesh meat.'''*

The account of a great catastrophe given in Ovid's description of the world on fire, and which is attributed to an astronomical event, undoubtedly refers to the Post-glacial disturbances. It is recorded in the myth of Phaëton, son of Phœbus—Apollo (the sun)—guiding the chariot of his father, who loses control of the horses of the sun while driving through the

* "The Shu King," p. 16, edit. Max Müller, Sacred Books of the East.

heavens, thereby causing an astronomical revolution, and coming so near to the earth as to set it on fire. Phaëton is finally killed by Jove in order to save the universe from complete destruction. Phaëton demands of his father the right to drive his chariot for one day, in order to prove his paternity. The latter reluctantly yields, after much persuasion, and in endeavoring to convince him of the enormity of the undertaking thus advises Phaëton :—

“ Besides, the heavens are carried round with a constant rotation, and carrying with them the lofty stars whirl them with rapid revolution. Against this I have to contend ; and that force which overcomes all things does not overcome me, and I am carried away in a contrary direction to the world.” But the pleadings of the son overcame his father, and the latter consented. The disastrous results arising from his incompetency to guide the chariot are recorded by Ovid. In the second book of his “*Metamorphoses*” he tells how the rivers and springs were dried up, while others boiled ; how the volcanoes were set in action, and emitted ashes, embers and smoke ; that great chasms were formed, and the mountains despoiled of their snow-caps ; how the delta of the Nile sank, and the mouths of the river became empty, and subsided into mere channels ; and of the encroachment of the sea on the land ; and how the moon was affected, and that one day passed without the sun.

“ The moon, too, wonders that her brother’s horses run lower than her own, and the scorched clouds send

forth smoke. As each region is most elevated it is caught by the flames and cleft: it makes vast chasms, its moisture being carried away. The grass grows pale," he says, "the trees with their foliage are burnt, and the dry standing corn affords fuel for its own destruction. But I am complaining of trifling ills. Great cities perish, together with their fortifications, and the flames turn whole nations with their populations into ashes: woods, together with mountains, are on fire. Athos burned, and the Cilician Taurus, and Tmolus, and Ceto, and Ida, now dry, but once most famed for its springs, and Helicon, the resort of the virgin muses, and Hæmus, not yet called Cægrian. Ætna burns intensely with redoubled flames, and Parnassus, with its two summits, and Eryx, and Cynthus, and Ortheys, and Rhodope, at length to be despoiled of its snows, and Mimas, and Dindyma, and Mycale, and Cithæron, created for the sacred rites. Nor does its cold avail even Scythia; Caucasus is on fire, and Ossa with Pinus, and Olympus, greater than them both, and the lofty Alps, and the cloud-bearing Apennines. Then was Lybia made dry by the heat, the moisture being carried off; then with disheveled hair the nymphs lamented the springs and the lakes. Bœotia bewails Dirce, Argos, Amymone, and Ephyre the waters of Pirene. Nor do rivers that have banks distant remain secure. Tanais smokes in the midst of its waters, and the aged Peneus and Teuthrastian Caïcus, and rapid Ismenus. . . . The Babylonian Euphrates, too, was on fire, Orontes was in flames, and the swift

Thermodon, and Ganges, and Phasis, and Ister. Alpheus boils; the banks of Spercheus burn; and the gold which Tagus carries with its stream melts in the flames. The river-birds, too, which made famous the Mæonian banks with song, grew hot in the middle of Cayster. The Nile, affrighted, fled to the remotest parts of the earth and concealed his head; his seven last mouths are empty, seven channels without any streams. The same fate dries up the Ismarian rivers, the Rhine, the Rhone, and the Po, and the Tiber, to which was promised the sovereignty of the world. All the ground burst asunder, and through the chinks the light penetrates into Tartarus, and startles the infernal king with his spouse.

“The ocean, too, is contracted, and that which lately was sea is a surface of parched sand; and the mountains which the deep sea had covered start up and increase the number of the scattered Cyclades.* The fishes sink to the bottom, and the crooked dolphins do not care to raise themselves on the surface into the air as usual. The bodies of sea-calves float helpless on their backs on the top of the water. The story, too, is, that even Nereus himself, and Doris, and their daughters, lay hid in the heated caverns.”

After referring to the destruction of Phaëton in the attempt to guide the chariot through the heavens, and the committal of his body to the tomb, Ovid continues: “But his wretched father (the sun) had hidden his face, overcast with bitter sorrow; and, if only we can

* A cluster of islands in the Ægean Sea.

believe it, they say *that one day passed without the sun*. The flames afforded light, and there was some advantage in that disaster."

After the entreaties of the deities to the sun not to determine to bring darkness over the world, the sun examines the earth and the works of man. "He restores, too, the springs and the rivers that had not yet dared to flow, green leaves to the trees, and orders the injured forests again to be green."

The foregoing is undoubtedly a graphic account of the result of the later Glacial event, the origin of which has been ascribed to heathen deities. It would require a great stretch of the imagination to conceive that such local events, so minutely described, are but pure fiction; for the details of the change of level and the numerous volcanic eruptions are too faithfully portrayed to have had but an imaginative origination.

Another authentic reference to the Glacial period is preserved in the Dialogues of Plato. The author tells how Solon, the great Athenian lawgiver, who flourished about 600 years before Christ, visited Egypt, and of his cordial welcome by the priests of that country, from whom he received much information about the antiquity of his own country as well as Egypt. His visit is thus described: "At the head of the Egyptian delta, where the river Nile divides, there is a certain district which is called the District of Sais, and the great city of the district is also called Sais, and is the city from which Amasis, the king, was sprung. And the citizens have a deity who is their

foundress: she is called in the Egyptian tongue Neith, which is asserted by them to be the same whom the Hellenes called Athene. Now, the citizens of this city are great lovers of the Athenians, and say that they are in some way related to them. Thither came Solon, who was received by them with great honor; and he asked the priests, who were most skilful in such matters, about antiquity, and made the discovery that neither he nor any other Hellene knew anything worth mentioning about the times of old. On one occasion, when he was drawing them on to speak of antiquity, he began to tell about the most ancient things in our part of the world—about Phoroneus, who is called the ‘the first,’ about Niobe; and after the Deluge, to tell of the lives of Deucalion and Pyrrha; and he traced the genealogy of their descendants, and attempted to reckon how many years old were the events of which he was speaking, and to give the dates. Thereupon one of the priests, who was of very great age, said, ‘O Solon, Solon, you Hellenes are but children, and there is never an old man who is an Hellene.’ Solon, hearing this, said, ‘What do you mean?’ ‘I mean to say,’ he replied, ‘that in mind you are all young; there is no old opinion handed down among you by ancient tradition, nor any science which is hoary with age. And I will tell you the reason of this: there have been, and will be again, many destructions of mankind arising out of many causes. There is a story, which even you have preserved, that once upon a time Phaëton, the son of Helios, having

yoked the steeds in his father's chariot, because he was not able to drive them in the path of his father burnt up all that was upon the earth, and was himself destroyed by a thunderbolt. Now, this has the form of a myth, but really signifies a *declination of the bodies moving around the earth and in the heavens, and a great conflagration of things upon the earth recurring at long intervals of time*: when this happens those who live upon the mountains and in dry and lofty places are more liable to destruction than those who dwell by rivers or on the sea shore; and from this calamity the Nile, who is our never-failing saviour, saves and delivers us. When, on the other hand, the gods purge the earth with a deluge of water, among you herdsmen and shepherds on the mountains are the survivors; whereas those who live in cities are carried by the rivers into the sea. But in this country neither at that time nor at any other does water come up from above on the fields, having always a tendency to come up from below, for which reason the things preserved here are said to be the oldest. The fact is, that wherever the extremity of winter frost or of summer sun does not prevent, the human race is alway increasing at times, and at other times diminishing in numbers. And whatever happened either in your country or in ours, or in any other region of which we are informed—if any action which is noble or great, or in any other way remarkable, has taken place, all that has been written down of old, and is preserved in our temples; whereas you and other

nations are just being provided with letters and the other things which States require; and then, at the usual period, the stream from heaven descends like a pestilence, and leaves only those of you who are destitute of letters and education; and thus you have to begin all over again as children, and know nothing of what happened in ancient times, either among us or among yourselves. As for those genealogies of yours which you have recounted to us, Solon, they are no better than the tales of children; for, in the first place, you remember one deluge only, whereas there were many of them; and, in the next place, you do not know that there dwelt in your land the fairest and noblest race of men which ever lived, of whom you and your whole city are but a seed or remnant. And this was unknown to you, because for many generations the survivors of that destruction died and made no sign. For there was a time, Solon, before that great deluge of all, when the city which is now Athens was first in war, and was pre-eminent for the excellence of her laws, and is said to have performed the noblest deeds, and to have had the fairest constitution of any of which tradition tells, under the face of heaven.' Solon marvelled at this, and earnestly requested the priest to inform him exactly and in order about these former citizens."

Then the Egyptian priest goes on to relate to Solon the history of Greek civilization as recorded in the sacred registers of Egypt, in which was ascribed an antiquity far greater than that of the kingdom of

Egypt, and of the sudden destruction by a deluge of Atlantis, an island in the Atlantic Ocean opposite the Mediterranean Sea, that was formerly the abode of a populous nation, and the home of an advanced civilization.

“Many great and wonderful deeds are recorded of your State in our histories,” said the Egyptian; “but one of them exceeds all the rest in greatness and valor; for these histories tell of a mighty power which was aggressing wantonly against the whole of Europe and Asia, and to which your city put an end. This power came forth out of the Atlantic Ocean, for in those days the Atlantic was navigable; and there was an island situated in front of the straits which you call the columns of Heracles. The island was larger than Lybia and Asia put together, and was the way to other islands, and from the islands you might pass through the whole of the opposite continent which surrounded the ocean; for this sea which is within the Straits of Heracles is only a harbor, having a narrow entrance; but that other is a real sea, and the surrounding land may be most truly called a continent. Now, in the island of Atlantis there was a great and wonderful empire, which had rule over the whole island and several others, as well as over parts of the continent; and besides these, they subjected the parts of Lybia within the columns of Heracles as far as Egypt, and of Europe as far as Tyrrhenia. The vast power thus gathered into one endeavored to subdue at one blow our country and yours, and the whole of the land

which was within the straits; and then, Solon, your country shone forth in the excellence of her virtue and strength among all mankind; for she was the first in courage and military skill, and was the leader of the Hellenes. And when the rest fell off from her, being compelled to stand alone, after having undergone the very extremity of danger, she defeated and triumphed over the invaders, and preserved from slavery those who were not yet subjected, and freely liberated all the others who dwelt within the limits of Heracles. But afterwards there occurred violent earthquakes and floods, *and in a single day and night* of rain all your warlike men in a body sunk into the earth, and the island of Atlantis in like manner disappeared, and was sunk beneath the sea. And that is the reason why the sea in those parts is impassable and unpenetrable, because there is such a quantity of shallow mud in the way; and this was caused by the subsidence of the island.”*

The sudden disappearance of Atlantis in a single day and night was undoubtedly the result of the change of level which accompanied the Glacial period. Many reliable accounts of destructive floods, which will be found to correspond in detail with the events of that epoch, have been preserved by the various Indian nations which inhabited Central America at the time of the Spanish conquest.

The Toltec legends tell of a time when “there was a tremendous hurricane that carried away trees, mounds,

* “Plato’s Dialogues,” II., 517, Timæus.

houses and the largest edifices, notwithstanding which many men and women escaped, principally in caves and places where the hurricane could not reach them. A few days having passed they set out to see what had become of the earth, when they found it all populated with monkeys. *All this time they were in darkness, without seeing the light of the sun nor the moon that the wind had brought them.*"*

The apparently incredible portion of this account is that referring to the vast assemblage of monkeys. But it is not difficult to understand how the superior agility of these animals would enable many of them to escape the coming calamity, and effect a passage through the trees to a place of safety, while other quadrupeds were caught in the approaching waters and swept away.

Father Bernardino de Sahagan, a Spanish Franciscan, and one of the first Mexican missionaries who labored in that country during the sixteenth century, carefully transcribed the following pitiful and pathetic prayer of the Aztecs to the great god Tezcatlipoca, the most important of the Mexican deities, and used by the priest during a time of pestilence. It appears to be offered on behalf of a surviving remnant of people who had escaped a disastrous calamity, and were surrounded by total darkness, waiting for the light of the sun, which had failed to rise, and which they never again expected to behold:—

"Oh mighty Lord, under whose wing we find defence and shelter, thou art invisible and impalpable,

* "North Americans of Antiquity," p. 239.

even as night and the air. How can I, that am so mean and worthless, dare to appear before thy Majesty? Stuttering, and with rude lips, I speak; ungainly is the manner of my speech, as one leaping among furrows, as one advancing unevenly; for all this I fear to raise thine anger, and to provoke instead of appeasing thee. O Lord, thou hast held it good to forsake us in these days, according to the counsel that thou hast as well in heaven as in hades; alas for us, in that thine anger and indignation has descended upon us in these days; alas, in that the many and grievous afflictions of thy wrath have overgone and swallowed us up, coming down even as stones, spears and arrows upon the wretches that inhabit the earth; this is the sore pestilence with which we are afflicted and almost destroyed. O valiant and all-powerful Lord, the common people are almost made an end of and destroyed; a great destruction the ruin and pestilence already make in this nation; and, what is most pitiful of all, the little children, that are innocent and understand nothing only to play with pebbles and to heap up little mounds of earth, they, too, die, broken and dashed to pieces as against stones and a wall—a thing very pitiful and grievous to be seen, for there remain of them not even those in the cradles, nor those that could walk or speak. Ah, Lord, how all things become confounded! of young and old and of men and women there remains neither branch nor root; thy nation and thy people, and thy wealth, are levelled down and destroyed.

“O our Lord, protector of all, most valiant and most kind, what is this ?

“Thine anger and thine indignation, does it glory or delight in hurling the stone, and arrow, and spear ? The fire of the pestilence, made exceeding hot, is upon thy nation, as a fire in a hut, burning and smoking, leaving nothing upright or sound. The grinders of thy teeth are employed, and thy bitter whips, upon the miserable of thy people, who have become lean and of little substance, even as a hollow green cane.

“Yea, what doest thou now, O Lord, most strong, compassionate, invisible and impalpable, whose will all things obey, upon whose disposal depends the rule of the world, to whom all are subject, what in thy divine breast hast thou decreed ? Peradventure hast thou altogether forsaken thy nation and thy people ? Hast thou verily determined that it utterly perish, and that there be no memory of it in the world ; that the peopled place become a wooded hill and a wilderness of stones ? Peradventure wilt thou permit that the temples, and the place of prayer, and the altars, built for thy service, be razed and destroyed, and no memory of them left ?

“Is it, indeed, possible that thy wrath and punishment and vexed indignation are altogether implacable, and will go on to the end of our destruction ? Is it already fixed in thy divine counsel that there is to be no mercy nor pity for us until the arrows of thy fury are spent to our utter perdition and destruction ? Is it possible that this lash and chastisement is not given

for our total correction and amendment, but only for our total destruction and obliteration; *that the sun shall nevermore shine upon us*, but that we must remain in *perpetual darkness and silence*; that never more wilt thou look upon us with eyes of mercy, neither little nor much?

“Wilt thou after this fashion destroy the wretched sick that cannot find rest, nor turn from side to side, whose mouth and teeth are filled with earth and scurf? Is it a sore thing to tell how *we are all in darkness*, having none understanding nor sense to watch for or aid one another. We are all as drunken and without understanding; without hope of any aid, already the little children perish of hunger, for there is none to give them food, nor drink, nor consolation, nor caress; none to give the breast to them that suck, for their fathers and mothers have died and left them orphans, suffering for the sins of their fathers.

“O our Lord, all-powerful, full of mercy, our refuge, though indeed thine anger and indignation, thine arrows and stones, have sorely hurt this poor people, let it be as a father or a mother that rebukes children, pulling their ears, pinching arms, whipping them with nettles, pouring chill water upon them, all being done that they may amend their puerility and childishness. Thy chastisement and indignation have lorded and prevailed over these thy servants, over this poor people, even as rain falling upon the trees and the green canes, being touched of the wind, drops also upon those that are below.

“O most compassionate Lord, thou knowest that the common folk are as children, that being whipped they cry and sob and repent of what they have done. Peradventure already these poor people, by reason of their chastisement, weep, sigh, blame and murmur against themselves; in thy presence they blame and bear witness against their bad deeds, and punish themselves therefor. Our Lord, most compassionate, pitiful, noble and precious, let a time be given the people to repent; let the past chastisement suffice; let it end here, to begin again if the reform endure not. Pardon and overlook the sins of the people; cause thine anger and thy resentment to cease; repress it again within thy breast that it destroy no further; let it rest there; let it cease, for of a surety none can avoid death, nor escape to any place.

“We owe tribute to death, and all that live in the world are vassals thereof; this tribute shall every man pay with his life. None shall avoid from following death, for it is thy messenger, in what manner howsoever it may be sent, hungering and thirsting always to devour all that are in the world, and so powerful that none shall escape; then, indeed, shall every man be judged according to his deeds. O most pitiful Lord, at least take pity and have mercy upon the children that are in the cradles, upon those that cannot walk. Have mercy also, O Lord, upon the poor and very miserable, who have nothing to eat, nor to cover themselves withal, nor a place to sleep; who do not know what thing a happy day is; whose days pass altogether

in pain, affliction and sadness. Than this were it not better, O Lord, if thou shouldst forget to have mercy upon the soldiers, and upon the men of war whom thou wilt have need of some time? Behold, it is better to die in war, and go to serve food and drink in the house of the sun, than to die in this pestilence and descend to hades. O most strong Lord, protector of all, lord of the earth, governor of the world, and universal master, let the sport and satisfaction which thou hast taken in this past punishment suffice; make an end of this smoke and fog of thy resentment; quench also the burning and destroying fire of thine anger; let serenity come, and clearness; let the small birds of thy people begin to sing and approach the sun; give them quiet weather so that they may cause their voices to reach thy highness, and thou mayest know them.

“O our Lord, most strong, most compassionate, and most noble, this little have I said before thee. I have nothing more to say, only to prostrate and throw myself at thy feet, seeking pardon for the faults of this my prayer; certainly I would not remain in thy displeasure, and I have no other thing to say.”*

The foregoing is evidently handed down from the Glacial epoch. Even if it became “padded” to a considerable extent through the course of time, or other circumstances, the gist undoubtedly corresponds with the events of that period.

The temporary absence of the sun is also referred to in the Aztec creation myths, in which it is related

* Bancroft's “Native Races,” Vol. III., p. 200.

that "there had been no sun in existence for many years; so the gods, being assembled in a place called Teotihuacan, six leagues from Mexico, and gathered at the time round a great fire, told their devotees that he of them who should first cast himself into that fire should have the honor of being transformed into a sun. So one of them, called Nanahuatzim—either, as most say, out of pure bravery, or as Sahagun relates, because his life had become a burden to him through a malignant disease—flung himself into the fire. Then the gods began to peer through the gloom in all directions for the expected light, and to make bets as to what part of the heavens he should first appear in. And some said here, and some said there; but when the sun rose they were all proved wrong, for not one of them had fixed upon the East."*

The sacred books of the Hindoos contain the records of two devastating floods—one occurring in the south of the Himalayas, and the other in the north. The Greeks have also preserved traditions of a similar deluge. The Persians also have recorded accounts of a great flood, which corresponds with the Drift, and the remarkable change of climate which followed is also pointed out. The mythology of the Celts and Scandinavians contain many references to devastating floods. The North American Indian tribes possess similar traditions also.

The Polynesian legends tell how those islands were once inundated and flooded by a great rain. With the

* Bancroft's "Native Races," Vol. III., p. 60.

exception of a small number who were saved on the island of Mbenga, all the people were swept away. The traditions of one group say that "in ancient time Taarva, the principal god according to their mythology, the creator of the world, being angry with men on account of their disobedience to his will, overturned the world into the sea, when the earth sank into the water, excepting a few *aurus*, or projecting points, which, remaining above the surface, constituted the present cluster of islands."*

Almost every nation in the world possess traditions or recorded accounts of a deluge; and on the supposition that they referred to the Noachian flood the great dissimilarity in the dates recorded gave them a vague and undefined authenticity. But while some of the more ancient nations undoubtedly have preserved a record of that event, many of the others are faithful and reliable descriptions of the Glacial periods, both in point of detail and chronological occurrence.

It would be unwise to cast aside the enormous mass of traditionary and mythological evidence—referring, as much of it does, to personages and places—as an agglomeration of pure fiction, and entirely without a shred of foundation.

"We may be sure," says Bancroft, "that there never was a myth without a meaning; that mythology is not a bundle of ridiculous fancies invented for vulgar amusement; that there is not one of the stories,

* Ellis' "Polynesian Researches," Vol. II., p. 57.

no matter how silly or absurd, which was not founded on fact, which did not once hold a significance,"*

The events of the Glacial periods, therefore, show a reliable basis for such accounts, and throw a new light over the hitherto uninterpretable mystery of mythology.

*Bancroft's "Native Races," Vol. III., p. 17.

CHAPTER XII.

THE RECENCY OF THE GLACIAL EVENTS.

UNDOUBTED proofs of changes of level having occurred throughout the globe during the Glacial period, the date at which these events took place remains to be shown. Although the drift is known and admitted by all to be of recent origin, yet by calculation based on a slow and gradual process of formation, its occurrence is estimated at hundreds of thousands of years ago. To this there is one conclusive and undeniably fatal objection. Human bones and animal remains have been found embedded in the drift. The question then arises, How long will bone, as a perishable substance, resist disintegration? Instances are known of Egyptian mummies, preserved by the best process of embalming ever known, having crumbled to dust on exposure to the atmosphere after a lapse of but 3,000 years. If some of the remains found imbedded in the drift were of greater antiquity the same should be expected of them. But many of them are in a tolerably fair state of preservation, which is undoubted proof that the Post-glacial event took place at a comparatively recent period.

The traditions of all nations point to the occurrence of great catastrophes within the period of their own

existence, and therefore after many of the great kingdoms of antiquity had been founded. There is no historical account of any nation living upon the earth at a period of 100,000 or 200,000 years ago. The events consequently must have occurred long after the introduction of man upon the earth, as further indicated by the abundance of flint and stone implements, and other works of art, found in the drift. In reply to the question, "What geological evidence have we that the residence of man in Europe has been longer than 6,000 years?" Sir William Dawson says: "The answer must be, Absolutely none, as far as the association of man with extinct animals is concerned. Further, when we consider the mode of occurrence and state of preservation of the remains, and their identity with the remains of modern American races, the very long periods assigned by some authors to the residence of man in Europe become ridiculous in their absurdity."*

The antiquity of man has been divided into three epochs by archæologists, known respectively as the ages of Stone, Bronze and Iron. In Europe the Bronze age has been dated back previous to the time of the Romans; and as the implements found in the drift belong to the age of Stone, which is sub-divided into two divisions, the Palæolithic and Neolithic—ancient and new—the latter period is held to have been long anterior to Roman history. But this means of estimating the antiquity of man cannot be received

* "Fossil Men," p. 228.

as absolutely reliable, for flint and stone implements are found in abundance in America that have been in use by Indians during the present century. Therefore the presence of stone implements in the Drift deposits cannot be definitely regarded as indicating an extremely remote period of time at which the Glacial events occurred. Respecting the later Stone age, or the period when implements of polished stone were in use, Sir William Dawson concludes "that there is no adequate geological reason for attributing the so-called 'Neolithic' men to any time older than that of the early Eastern empires, or say 2,000 or 3,000 years before Christ; and that the time required for the Palæolithic men need not be more than twenty or thirty centuries additional."* As attested by animal remains found imbedded in the drift, the Post-glacial event occurred within a period at which they would resist decay. It occurred when civilization was far advanced, and after many of the great nations of antiquity had been founded, as indicated by the traditions of these nations of great catastrophes having taken place during the early period of their existence as such.

The two events were caused by an upward and downward shift of the North Pole, as explained by the great changes of level, and other evidence of upheaval and subsidence, by which the Glacial period was accompanied. They were sudden and instantaneous in action, as shown by the remarkable uniformity of the

* "Fossil Men," p. 246.

terrace lines and the wide interval by which they are separated from each other. If the action had been slow and gradual the waters could not have dropped or risen from one terrace to another, and the latter could not have maintained a perfectly horizontal level. The traditions of all nations point to an astronomical revolution as the cause, and in which the sun and the moon played an important part. This is also attested by the presence of meteorites in the drift.

The disturbances were therefore universal and catastrophic. The first came suddenly from the north, like a fearful cyclone, with a force so mighty that it decomposed the underlying rocks, smashed, pounded and tore down the gigantic mountain tops, and rooted up enormous trees growing on the surface, and scattered them for hundreds of miles, extending over the western hemisphere from the North Pole to the temperate regions; and if it had been gradual in its action the diurnal revolution of the earth on its axis would have carried it around the globe in twenty-four hours. It is evident, then, that the earth had ceased to revolve on its axis, the blow came instantaneously, and the Drift was the result of a gigantic catastrophe, a mighty and violent cataclysm, that nearly blotted the earth out of existence. It came instantaneously, suddenly arresting the rotary motion of the earth, and with a tremendous force hurled it bodily from its course, like a stone shot from a sling. This was again followed in course of time by a second event of a similar nature, and almost as destructive in its effects.

Figuier says: "We need not hesitate to confess our ignorance of this strange, this mysterious, episode in the history of our globe. . . . Nevertheless we repeat, no explanation presents itself which can be considered conclusive; and in science we should never be afraid to say, I do not know."

CHAPTER XIII.

THE STANDING STILL OF THE SUN.

WHEN the Israelites were in bondage in Egypt so complete was their slavery they might have continued in captivity while Egypt remained a nation had it not been for Divine intervention. Moses was chosen to deliver them from their affliction, and after the performance of many signs and wonders in the land of Egypt led the Israelites from bondage, and accompanied and guided them during their wanderings in the desert to which they had been condemned. After the borders of Canaan had been reached Moses died, and Joshua was appointed to succeed him in the command. He engaged and defeated his enemies in many a desperate conflict, for God had said to him: "There shall not any man be able to stand before thee all the days of thy life: as I was with Moses, so I will be with thee: I will not fail thee, nor forsake thee."* Jericho and Ai had fallen into his hands. Gibeon had made peace with Israel, and the five kings of the Amorites combined together to make war upon Gibeon. In their distress the men of Gibeon sent to Joshua, to the camp at Gilgal, saying: "Slack not thy hand from thy servants; come up to us quickly, and save

* Joshua i. 5.

us, and help us: for all the kings of the Amorites that dwell in the mountains are gathered together against us. So Joshua ascended from Gilgal, he, and all the people of war with him, and all the mighty men of valor. And the Lord said unto Joshua, Fear them not: for I have delivered them into thine hand; there shalt not a man of them stand before thee.”*

Joshua left Gilgal at night and came upon the Amorites suddenly, and slew them with a great slaughter. The Israelites chased and smote them till sundown. The evening shadows were beginning to lengthen, the sun was disappearing in the west, and Joshua saw that the enemy would escape him in the coming darkness. “Then spake Joshua to the Lord in the day when the Lord delivered up the Amorites before the children of Israel, and he said in the sight of Israel, Sun, stand thou still upon Gibeon; and thou, Moon, in the valley of Ajalon.”†

Quicker than a lightning flash the command was obeyed, and as with a thunderbolt the foundations of the universe were shaken. The sun instantly lost its axial motion and power of attraction, and the planets flew in all directions, like sparks from a blacksmith’s anvil. Slanting obliquely on its axis at an angle of twenty-three and a half degrees, and released from the centripetal influence of the sun, the earth instantly bounded upright to gain its equilibrium, and in a line tangential to the course of its orbit shot off like a meteor into the realms of space. The whole of the polar

* Joshua x. 6-8. † *Ib.*, x. 12.

regions, consisting of incalculable tons of mountainous ice and snow, were instantly precipitated down that mighty incline, and over the face of the north-western hemisphere. The molten, seething mass of incandescent matter in the centre of the earth boiled and bubbled. Great cracks or fissures were reft through the crust of the earth in many places, and released the imprisoned cauldron of molten matter, and this poured over the surface in devastating torrents for many miles. Shooting through illimitable space the earth flew as a meteor. "Darkness was upon the face of the deep." No sun, no moon, and the stars shooting by in all directions, their flashing faintly discernable amid the glare of volcanic flame and clouds of smoke and steam. Great whirlwinds, hurricanes and cyclones were created, and struggled with the raging fire and water for the mastery. Trees, rocks, boulders, animals and every conceivable thing were carried into the air, whirled round and round, and violently hurled into the raging, tempestuous jam of icebergs in the waters below. Every hill became a Niagara, every valley a whirlpool, and every fissure in the rocks a raging maelstrom, into which the marine and land animals were drawn and torn to pieces. The mountains leaned at an incline, deposited their snow-caps in the valleys below, and over their tops the raging torrents poured in mighty cascades. Along the surface of the earth that terrible ice-jam tore, scratched, and plowed those striated groves and furrows which centuries of time have failed to efface. The birds of the air were en-

veloped in storms of ice, gravel and frozen spray ; and on the land bordering the drift the broken ice and hail were showered for miles. Every living thing caught in that raging flood of crunching ice was torn to pieces and instantly destroyed. In its onward course the mightiest cataract in the world would be as a rivulet compared with that tremendous and dreadful catastrophe.

On the other side of the globe a different scene was taking place. Many of the rivers and streams were dried up, while others changed their courses, and the sun, just above the horizon in the western heavens, looked down with a pale, feeble glare on the swiftly receding earth. The battle between Joshua and the Amorites had been decided when the sun ceased to go down, but the work of slaughter had only commenced. Separated from the flood on the other side of the globe by the time of distance the sun was above the horizon, Joshua and his warriors were beyond the reach of danger, and pursued their enemies into the borders of that awful cataclysm, and "they were more which died with hailstones than they whom the children of Israel slew with the sword." On and on the earth flew and trembled in its mad career, dragging the helpless moon behind, while the battle with the elements raged. Nearly a whole day had passed. The earth had travelled far beyond the line of its former orbit. Joshua's enemies had perished, and the victory was complete. The sun had done its duty, as commanded, and God once more set it in motion. Instantly

the sun revolved on its axis, and the planets strove to regain their former positions, but at their increased distance from the sun the power of attraction was diminished, according to the inverse squares of the distance, and the earth failed to reach its former incline and remained upright. Then whirling once more on its axis it flew off in a path lying far beyond that of its former orbit. The work of slaughter and destruction was over. The waters became peaceful, and the floating rocks, boulders, stones, gravel, and everything that escaped trituration, were suddenly precipitated to the bottom in a conglomerated heterogeneous mass. The trituration of the ice upon the rocks formed that tough, unstratified, unfossiliferous bed of deposit known to geologists as "till," or "hard pan," the true origin of which is a puzzle and a mystery to the scientific world.

Thus was fulfilled the promise God gave to Joshua on appointing him to the command of the Israelites: "Be strong and of a good courage; be not afraid, neither be thou dismayed: for the Lord thy God is with thee whithersoever thou goest."*

This wonderful event took place Anno Mundi, 2553, or 1451 years before the birth of Christ, and "there was no day like that before it or after it, that the Lord hearkened unto the voice of a man: for the Lord fought for Israel."†

* Joshua i. 9.

† *Ib.*, x. 14.

CHAPTER XIV.

THE INTER-GLACIAL PERIOD.

WHEN that long night of terror and darkness in the western hemisphere had passed, in which death and destruction stalked hand in hand over the country and blotted out of existence all animal and vegetable life in their path, and the rays of the rising sun had struggled through the accumulated clouds and mists, a scene of utter devastation and desolate grandeur must have presented itself.

After the icebergs had melted, great walls of loose detrital accumulations remained in the valleys connected with high mountain chains. These were composed of masses of stones, gravel and broken rocky material, which had been carried down by the ice, and are known as moraines. Where this *debris* has been pushed forward and deposited at the lower extremity of the glaciers it is found to have always terminated in a semi-circular form. These terminal moraines mark the lower limit of stranded ice, and in the wide marginal depressions formed by the glaciers masses of loose material, composed of fragmentary rock, etc., have been accumulated, known as lateral moraines. These ancient deposits are now covered with soil on which vegetation has long since grown, and some of

the largest trees flourish. In Europe cities and villages have been built upon ancient moraines. Upon these the foundations of Berne and Zurich, and other cities, are laid. Some extend completely across entire valleys, through which overflowing rivers have since cut their way. The whole surface of the Western world had undergone a complete metamorphosis. The land in many places had become completely inundated, and vast inland seas had taken the place of the previous fertile valleys and plains. The old river channels were obliterated and new ones formed, and an entirely different geographical aspect was the result. The entire world felt the effect of the shock, in the east as well as in the west, and the climate of the globe underwent a complete and sudden change, in which the fauna and flora of temperate and tropical regions invaded that of the Arctic, and those of the latter inhabited the lower latitudes. Remains of plants and animals have been found in Northern Siberia, Europe and America that could only exist in temperate and tropical climates, and they are too numerous and perfect to lead to the supposition that they have been carried from a distance and deposited there. Oaks, beech and other similar remains have been found in great quantities in the Arctic regions; and the remains of huge animals, such as the elephant and mastodon, have been found imbedded in the frozen ice and gravel of the north. From this it is clearly evident that for a period of time the polar regions were once clear of ice, and enjoyed a climate similar

to that in which such fauna and flora could exist at the present day. But while the ice and snow disappeared from the north, and the temperature of those regions became much higher than formerly, the climate of the present tropical regions became much colder. "More extended observations," says Lyell, "have shown that in times past the climate of the extra tropical regions has by no means been hotter than now; on the contrary, there has been at least one period, and *one of very modern date*, geologically speaking, when the temperature of those regions was much lower than at present."*

"In the so-called drift," Agassiz remarks, "there are found far to the south of their present abode the remains of animals whose home now is in the Arctics or the coldest parts of the temperate zones. Among them are the musk-ox, the reindeer, the walrus, the seal, and many kinds of shells characteristic of the Arctic regions. The northernmost part of Norway and Sweden is at this day the southern limit of the reindeer in Europe; but their fossil remains are found in large quantities in the drift about the neighborhood of Paris, and quite recently they have been traced even to the foot of the Pyrenees, where their presence would, of course, indicate a climate similar to the one now prevailing in Northern Scandinavia. Side by side with the remains of the reindeer are found those of the European marmot, whose present home is in the mountains, about 6,000 feet above the level of the sea.

* "Text-book of Geology," Vol. I., p: 175.

The occurrence of these animals in the superficial deposits of the plains of central Europe, one of which is now confined to the high north, and the other to mountain heights, certainly indicate an *entire change of climatic conditions* since the time of their existence. European shells, now confined to the Northern Ocean, are found as fossils in Italy, showing that while the present Arctic climate prevailed in the temperate zone, that of the temperate zone extended much further south to the regions we now call sub-tropical. In America there is abundant evidence of the same kind; throughout the recent marine deposits of the temperate zone, covering the lowlands above tide water on this continent, are found fossil shells whose present home is on the shores of Greenland. It is not only in the northern hemisphere that these remains occur, but in Africa and in South America, wherever there has been an opportunity for investigation, the drift is found to contain the traces of animals whose presence indicates a climate many degrees colder than that now prevailing there."*

The Himalaya Mountains, in India, bear unmistakable evidence of having deposited their snow-caps down their southern slopes at this time. Moraines abound, and erratics of great size have been seen far above the level of the sea, though no marks of glaciation have been observed in Southern India; but there is a distinct evidence in the fauna and flora on the south of the mountains of a temporary change of climate having occurred.

* "Geological Sketches."

In Asia the whole of the northern part of that continent became the home of numerous and gigantic mammals that existed during this period.

Many theories have been advanced as to the cause of the sudden change of temperature in the climate of the earth, though no satisfactory solution of the difficulty has yet been found. It seems to be generally believed, however, that it resulted from "the combined influence of precession of the equinoxes and secular changes in the eccentricity of the earth's orbit." According to this idea it is held that the North Pole is constantly but gradually changing its position, and that every 10,500 years it becomes reversed, the incline being in the opposite direction. The effect thus produced is held to be longer and colder winters and shorter and hotter summers in the northern hemisphere. By the increasing eccentricity the effects would be greatly augmented. When the eccentricity was greatest the earth would be 14,000,000 miles further from the sun during winter than in the summer. In combination with different geographical causes, such as the varied distribution of land and water, etc., the climate is supposed to have become gradually colder, and a Glacial period the result. But to this there are one or two fatal objections. If the earth has had an existence of many millions of years, as the advocates of this theory maintain, a repetition of Glacial periods must have occurred in the past. There is no geological evidence of more than one having taken place, and that is of the most recent occurrence. Again, this

Arctic climate is supposed to have existed for over 100,000 years, and its intensity so severe as to freeze water into solid ice 6,000 feet thick. Under such conditions animal life could not exist, or find means of subsistence; and if it did, the fauna must have been one specially adapted for its surroundings. No evidence of such has ever been found. The animals of the Glacial period were similar in their habits to those at present existing in temperate and warm climates, and they could not possibly have lived under such conditions for an extended length of time. If the remains of the woolly rhinoceros, mammoth and reindeer, found in the drift, are to be held indicative of a prolonged and gradual refrigeration, the contemporaneous existence of the hippopotamus and hyena—animals suited to a warm climate—is an implication to the contrary. These facts alone are certainly conclusive evidence against the theory of gradual refrigeration, which also fails to explain any of the peculiarities connected with the drift.

Almost every available and conceivable cause known has been advanced in the endeavor to solve the mystery. "At first it was imagined," says Lyell, "that the earth's axis had been perpendicular to the plane of the ecliptic, so that there was a perpetual equinox and uniformity of seasons; that the planet enjoyed this paradisaical state until the era of the flood, but in that catastrophe lost its equipoise, whether by the shock of a comet or other convulsion, and hence the obliquity

of its axis, and with it the varied seasons of the long nights and days of the polar circles."

Having ascertained the cause of the shock it can be easily understood how the change in temperature occurred. The perpendicular position of the earth during the Inter-glacial period would result in a perpetual equinox and uniformity of seasons. The climate would be slightly varied as the earth approached to or receded from the sun. The heat of the sun's rays which are now concentrated on the tropics would be spread over the whole globe, hence a lower temperature would result in the tropical regions. Thus it can be seen how an exchange of the fauna and flora of these regions could have taken place, which they did during this period.

For more than seven centuries the earth maintained an upright position, and while on its new orbit deposits of a different nature were accumulated over that portion of the drift known as the till. These formed the intercalary layers, occasionally met with in some parts of the drift; and this was covered with a final overlay of gravel and boulders by another sudden and violent cataclysm, though not so destructive as the first, but occurring in almost a similar manner.

"During the Inter-glacial period a tropical climate had prevailed over a great part of the earth, and animals, whose home is now beneath the equator, roamed over the world from the far south to the very borders of the Arctic. The gigantic quadrupeds—the mastodons, elephants, tigers, lions, hyenas and bears—whose

remains are found in Europe, from its southern promontories to the northernmost limits of Siberia and Scandinavia, and in America, from the Southern States to Greenland and the Melville Islands, may, indeed, be said to have possessed the earth in those days. But their reign was over. A sudden, intense winter, that was also to last for ages, fell upon our globe. It spread over the very countries where these tropical animals had their homes; and so suddenly did it come upon them that they were embalmed beneath masses of snow and ice, without time even for the decay which follows death."* What was it?

* Agassiz's "Geological Sketches."

CHAPTER XV.

THE POST-GLACIAL PERIOD.

WHEN Hezekiah was king of Judah he made great efforts to reform his kingdom from idolatry, and to lead the people to the worship of the true God. Scripture tells us that "In those days was Hezekiah sick unto death. And the prophet Isaiah the son of Amoz came to him, and said unto him, Thus saith the Lord, Set thine house in order; for thou shalt die, and not live. Then he turned his face to the wall, and prayed unto the Lord, saying, I beseech Thee, O Lord, remember now how I have walked before Thee in truth and with a perfect heart, and have done that which is good in Thy sight. And Hezekiah wept sore. And it came to pass, afore Isaiah was gone out into the middle court, that the word of the Lord came to him, saying, Turn again, and tell Hezekiah the captain of My people, Thus saith the Lord, the God of David thy father, I have heard thy prayer, I have seen thy tears: behold, I will heal thee: on the third day thou shalt go up unto the house of the Lord. And I will add unto thy days fifteen years; and I will deliver thee and this city out of the hand of the king of Assyria; and I will defend this city for Mine own sake, and for My servant David's sake. And Isaiah

said, Take a lump of figs. And they took and laid it on the boil, and he recovered.

“And Hezekiah said unto Isaiah, What shall be the sign that the Lord will heal me, and that I shall go up into the house of the Lord the third day? And Isaiah said, This sign shalt thou have of the Lord, that the Lord will do the thing that He hath spoken: shall the shadow go forward ten degrees, or go back ten degrees? And Hezekiah answered, It is a light thing for the shadow to go down ten degrees: nay, but let the shadow return backward ten degrees. And Isaiah the prophet cried unto the Lord: and He brought the shadow ten degrees backward, by which it had gone down in the dial of Ahaz.”*

“So the sun returned ten degrees, by which degrees it was gone down.”†

NOTE.—Sundials used in ancient times were of various forms. That of King Ahaz consisted of a flight of stairs, on which was cast the shadow of an obelisk, or column, at the top, which fell on a number of them according to the position occupied by the sun.

Though there is no record of the means employed to cause the shadow to go back on the dial, it can be seen that instead of the sun standing still, as in the days of Joshua, by which the whole solar system was affected, the rotary motions of the latter were arrested, while the sun remained undisturbed. As a consequence the revolutionary motion of the earth was overcome by the centripetal influence of the sun, and it was gradually drawn back in an elliptical course

* 2 Kings xx. 1-11.

† Isaiah xxxviii. 8.

to its former orbit. Deprived of all power of resistance, and overcome by the magnetic attraction of the sun, the earth was drawn down at the North Pole from the upright position it then occupied to its former and present obliquity of twenty-three and one-half degrees. In the western hemisphere the southern part of the globe became elevated, and the waters of the Antarctic region swept into the south temperate latitude. The whole world suffered from the effect of the sudden shock, which was accompanied by all the phenomena attending the previous one, and was almost equally as destructive and devastating in its effects. In some places the underlying rocks were actually boiled and decomposed, owing to the intense heat of the earth, caused by the sudden shaking of the molten material in its centre. The volcanoes in all parts of the globe were set in motion. Immense fissures or cracks were opened in the crust of the earth down through the solid rocks; and where these were not deep enough to release the internal glowing mass, they formed what is known as fjords and friths, which exist in Scandinavia, Britain and other countries. Total darkness, boiling and raging floods, flying *debris*, inconceivable whirlwinds of gravel and hail, and an utter obliteration of all animal life that existed in its path, were the accompaniments of this terrible cataclysm in the southern hemisphere. While the deluge lasted the waters of the Arctic regions poured over the North Pole into the Northern Ocean and down into Siberia, overflowing the rivers and suddenly

blotting out of existence the huge mammals and other animals that roamed that country during this period. After the earth had travelled back to the line of its former orbit, and the shadow gone backward on the dial ten degrees, it was again set in rotating motion. Instantly whirling on its axis its velocity increased, and the earth shot off in a circle around the sun in its present orbit, and the one it had previously occupied before the time of Joshua. In this manner were formed what is known as *ösars*, *eskers*, or *kames*—long ridges of drift material whirled round into circular and semi-circular forms by the centrifugal action of the water, caused by the revolution of the earth upon its axis. In the tropical seas the bases of the coral reefs were thus formed. A sudden change in temperature instantly occurred, owing to the earth's obliquity, and in twenty-four hours the polar regions were again refrigerated. And this is why the remains of the elephant and mastodon, and other large animals, have been found in Siberia, and elsewhere in the north, imbedded in frozen gravel and ice; some of the carcasses so complete that dogs chewed and devoured the flesh when thawed, showing that they had been unexpectedly caught in the flood and drowned, and their remains preserved entire for centuries in the perpetual ice and frost of the Arctic regions.

Referring to this Cuvier says: "If they had not been frozen as soon as killed, putrefaction would have decomposed them; and, on the other hand, the eternal frost could not have previously existed in the place

where they died, for they could not have lived in such a temperature. It was, therefore, at the same instant when these animals perished that the country they inhabited was rendered glacial. *These events must have been sudden, instantaneous, and without any gradation.*”*

In “The World before the Deluge” Figuier says: “The animals seem to have perished *suddenly*; enveloped in ice at the moment of their death, their bodies have been preserved from decomposition by the continual action of the cold. As Agassiz says, in his first work on Glaciers: ‘A vast mantle of snow and ice covered the plains, the valleys and the sea. All the springs were dried up; the rivers ceased to flow. To the movements of a numerous and animated creation succeeded the silence of death.’ Great numbers of animals perished from cold; the elephant and rhinoceros perished by thousands in the midst of their grazing grounds, which were suddenly transformed into fields of ice and snow. It was then that these two species disappeared, and seem to have been effaced from creation. Other animals were overwhelmed without their race having been, always, entirely annihilated. The sun, which lately lighted up the verdant plains as it dawned upon these frozen steppes, was only saluted by the whistling of the north winds and the horrible rending of the crevasses, which opened up on all sides under the heat of its rays acting upon the immense glacier which formed the sepulchre of many animated beings.”

* “Ossements fossiles, Discours sur les Revolutions du Globe.”

Of the destructive results another authority says: "In America, in Britain and in Europe the Glacial deposits made clean work of nearly all animal life. The great mammalia, too large to find shelter in caverns, were utterly swept away, while others never afterwards returned to those regions. In like manner palæolithic man—man of the rude and unpolished flint implements, the contemporary of the great mammalia, the mammoth, the hippopotamus and the rhinoceros—was also stamped out; and the cave deposits of Europe show that there was a long interval before he appeared in those regions. The same forces, whatever they were, which smashed, and pounded, and contorted the surface of the earth, crushed man and his gigantic associates out of existence."

A downward shift of the North Pole having occurred it can thus be seen how the animals in Siberia escaped destruction, only to be entombed completely in the frozen ice. Had they been caught in the seething torrent, like those in the southern hemisphere, they would have been torn to pieces in that mighty jam of rocks, boulders, gravel and raging water. And though the Drift deposits are not found in Siberia, the country became inundated with water from the overflow of the Northern Ocean, and with it occurred the sudden extinction of the tropical and temperate fauna and flora that then existed in the Arctic regions.

In those vast mountains of snow and ice in the North; in that desolate and dimly-lighted wilderness, where animal life can scarcely exist; in the deep,

silent and dreary solitudes of death, unbroken only by the moaning and roaring of the blinding and drifting storms, where other suns and moons seem to mock at Nature, buried down in unknown depths beneath the ice and snow in frozen sepulchres, lie the remains of animal life which once lived and roamed in the North, in a time when a temperate flora grew in Greenland, Spitzbergen, and the Arctic zone. In silent voices they tell of a Polar Eden in the past, and bear testimony to the inscrutable working in nature of One who "withholdeth the waters, that they dry up," and "sendeth them out, and they overturn the earth," and who said, "Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed."

CHAPTER XVI.

MANNER AND TIME OF THE STANDING STILL OF
THE SUN.

MANY opinions have been advanced as to whether the lengthening of the day by the standing still of the sun and moon in the time of Joshua, and the regression of the shadow upon the dial in the days of Hezekiah, were physical or only apparent; but the latter idea has been largely adopted, and the former has become a subject of ridicule and scorn by the advocates of agnosticism and infidelity.

It has been held "that the whole effect wanted in that case, and fully answering the description of the apparent phenomenon as recorded, would be produced by an alteration in the refracting and transmitting properties of the atmosphere immediately over the part of Judea where the victory was obtained."*

Granting that such was the case, and the result only apparent, then the Scripture must be assumed untrue; for it is recorded, "The sun *stood* still."† There is no need, then, to advance such a theory as the foregoing, or one at all, to account for an effect that could not have taken place if the account is a deliberate untruth. If the recorded cause which produced the

* Smith's "Geological Science."

† Joshua, x. 13.

effect did not take place there could have been no result whatever. And if the effect be true that the day was lengthened, then the cause must be true, or there would have been no result. The sun either stood still or it did not. If it did, the effect narrated in Scripture actually took place; and if it did not, it is idle to advance any hypothesis to account for the lengthening of the day, a result that never could have occurred. A general theory is that mentioned by Whiston: "Whether the lengthening of the day, by the standing still of the sun and moon, were physical and real, by the miraculous stoppage of the diurnal motion of the earth for about half a revolution, or whether only apparent, by aerial *phosphori* imitating the sun and moon as stationary so long, while clouds and the night hid the real ones, and this parhelion, or mock sun, affording sufficient light for Joshua's pursuit and complete victory (which aerial *phosphori* in other shapes have been more than ordinarily common of late years), cannot now be determined; philosophers and astronomers will naturally incline to this latter hypothesis."* But why should they incline to the latter hypothesis if they are willing to admit the effect and concede that the day was lengthened? Let it be asked, What would be the result if the sun were to be suddenly extinguished? Total darkness and intense cold. Then what would be the result if the earth lost its centrifugal force and ceased to revolve on its axis? It would be gradually drawn towards the sun. And if the sun ceased to re-

* "Life of Josephus,"

volve and lost its centripetal influence over the planets, what then? By the force of their centrifugal motion they would fly off in a straight line. The result in this instance would be cataclysms such as have been recorded.

“When a body revolves on its axis the outer parts, of course, acquire motion. The tendency of the motion of these parts is, in reality, *to go on in a straight line*. They are only kept within the circle of revolution because they are fixed. If any piece of the revolving body were suddenly detached or let loose *it would be seen to fly off in a straight line*, being forced or impelled to do so by the motive power or force already exerted upon it. We may observe this law operating when we whirl a stone round in a sling. The stone is then felt to have an inclination to start away; and if we suddenly let slip the string it does start away with great speed. The tendency thus produced is called centrifugal (that is, centre-flying) force, in distinction from the force that holds the body from going out of the circle, which is sometimes called centripetal (centre-seeking) force. In consequence of centrifugal force the planets, in whirling round the sun, have a tendency to fly away into space; *and they would fly if they were not retained in a particular path or orbit by the attractive power of the sun.*”*

It is generally agreed that if the earth suddenly stood still the effect produced would be so enormous that every movable thing would be thrown off it, in

* Chambers' "Introduction to the Sciences," p. 18.

a manner similar to the results which would arise from the instantaneous stoppage of a railway carriage while travelling at full speed. But in this instance the earth did not stand still, but merely continued its former course in a straight line, instead of a curve, after its rotary motion became arrested. Scientists hold that even if such were the case the waters of the oceans would overflow the land in one devastating torrent. Granted. That is exactly what did occur. The waters of the Arctic Ocean swept over the face of the northern hemisphere, carrying with them the innumerable and enormous icebergs of that region, the imprint of which is still so plainly discernible in the rocks lying in the route over which they passed.

As an objection to the account of the recession of the shadow on the dial in the days of Hezekiah it is held that the event need not be considered universal, but merely confined to the shadow on the dial of Ahaz, which went backward ten degrees. Therefore it would not be necessary to suppose that other dials were similarly affected; and if such an event actually took place it was merely local, and confined to a single dial. But this objection is offset by the historical statement, mentioned in 2 Chron., xxxii. 31, that ambassadors came "from a far country, even from Babylon," to inquire of Hezekiah, "of the wonder that was done in the land." As the effects of the recession were apparent in a distant country it is quite evident the event must have been universal.

The recession of the shadow on the dial may be ex-

plained in the manner following:—According to the laws of motion, when a body passes over equal spaces in equal times the movement is said to be uniform. A ball thrown by the hand would continue in a straight line, with a uniform velocity, if its motion met with no opposition from any other force. The ball being inert has no power to stop of its own accord; but the force of projection being finally overcome by that of gravity the ball falls to the ground.

If the earth, in its course around the sun, were suddenly deprived of its rotary motion, while the sun still continued to exert over it the same influence as usual, the earth would be drawn in the direction of the sun. The path described would then be elliptical, and not in a direct line, owing to the force of projection being lessened, and that of gravity being continually accelerated as the earth approached the sun.

Moving in its orbit the path described by a planet depends upon its initial velocity and its distance from the sun. If its rotary motion were suddenly arrested the initial velocity would then be less than before, and cause it to move in an ellipsis, with the sun in one of the foci and the starting point its aphelion.

All objects on the earth have a motion in common with it, and a movement of this kind would cause a regression of the shadow on the dial such as that recorded to have taken place. After the earth had reached the intersecting point in the line of its former orbit an axial motion was imparted to it, which caused the globe to travel outward from its elliptical path

into its present and original course, by reason of the increase in its initial velocity. As the earth flew away from the sun at a point tangential to its orbit when the sun stood still, the same point could not be reached again by the earth except in a straight line. The homeward path being elliptical the course back would be by a considerably nearer route. The distance from the outer to the inner orbit would be therefore traversed by the earth in about one-half the time required by the globe to have gone forward, at the same time bringing back the shadow on the dial ten degrees, by which it was gone down.

Geologists refuse to entertain for a moment the occurrence of miracles in connection with the formation of the whole or any portion of the globe, and allow of no other aid but the known forces now in operation. These have been found altogether inadequate to account for its existence in its entirety within a reasonable and known period, and Geology has been compelled to look elsewhere for further assistance. Discarding the idea of a First Cause working in nature it calls to its aid instead a period of time so remote as to be beyond the comprehension of human intelligence; and during a long series of ages, which the imagination reels in the endeavor to contemplate, the heaven and the earth are supposed to have been slowly and gradually formed. Surely the aid of miracles, by which Infinite Power only is employed, and by which natural results have followed, is equally as intelligible and far more suitable to the purpose than

the assumption of indefinite ages of time, of which history gives no record, and which has existed only on supposition. If supposition in the matter of time is admitted in Geology, it is but fair that the aid of Infinite Power, by which miracles could be performed, and of which history and chronology attest to have been actual facts, should be also allowed. By the aid of Infinite Power in place of indefinite time the same results may be obtained within a period known and corroborated by historical facts to have actually existed.

Most of the earlier geologists were of the opinion that the Drift deposits were the result of a great catalysm, but failed to identify it with the Noachian deluge, as the effects had not been universal. "If anything in Geology be established," said Cuvier, "it is that the surface of our globe has undergone a great and sudden revolution, the date of which cannot be referred to a much earlier period than 5,000 or 6,000 years ago." He pointed out that as the Ethiopian, Mongolian and Caucasian races existed upon the earth at the time, and escaped its effects from all directions, it could not have been universal.

What at first sight might seem an almost insuperable objection to the occurrence of a deluge of any great magnitude at such a modern period as the days of Hezekiah is the fact that about that time many of the great nations of antiquity began to rise. The kingdoms of Media and Macedonia had already been founded, and the rise of the Babylonian empire, or the era of Nabonassar, was in the year 747 B.C. In 743

B.C. the Spartans were engaged in the first Messenian war, when Hezekiah was but a child, and the city of Rome was founded in the year 753 B.C. Even previous to these periods many of the kingdoms of antiquity were well advanced in civilization and arts. The Greeks computed their history from the first Olympiad, which dates as far back as 776 B.C., and earlier still, in 797 B.C., the kingdom of Lydia was founded. The eighth century B.C. marks the starting point from which the great nations of antiquity sprang into existence; and if such a world-convulsing event as the last great continental upheaval of the Glacial epoch occurred during that period the history of these kingdoms should contain some reliable reference thereto. This they certainly do, as shown in their traditions. That these nations were not swept out of existence altogether may be explained by the fact that they were located near the equatorial regions, and thus escaped the more destructive results of the floods. The Glacial disturbances were polar phenomena, gradually extending into the temperate latitudes; while in the equatorial region the results were more of a local nature, and consequently not so destructive as in the northern and southern portions of the globe. But that they were of a violent nature, and that the latter of the events occurred in comparatively modern times, is vouched for by historians of that period. In the fifteenth book of "The Metamorphoses" Ovid tells that Pythagoris came to the city of Crotona, and in expounding the principles of his philosophy said: "I

have beheld that as sea which once had been the most solid earth. I have seen land made from the sea; and far away from the ocean the sea shells lay, and old anchors were found there on the tops of the mountains. That which was a plain a current of water has made into a valley, and by a flood the mountain has been levelled into a plain; the ground that was swampy is parched with dry sand, and places which have endured drought are wet with standing pools. Here Nature has opened fresh springs, but there she has shut them up; and rivers have burst forth, aroused by ancient earthquakes; or, vanishing, they have subsided." And then he tells how rivers were swallowed by chasms in the earth, and flowing with their streams concealed sprang up afresh at other places; that others were altered in their courses, and flowed in another direction; and how water, formerly used for drinking, became impregnated with bitter salts; that islands, once surrounded by waves, became peninsulas, and peninsulas became islands, and the island of Sicily, which had been united to Italy, was cut off from the neighboring region by waves flowing between. "Should you seek Helice and Buris, cities of Achaia," he says, "you will find them beneath the waves; and the sailors are still wont to point out these levelled towns, with their walls buried under the water. . . . So Troy was great, both in her riches and in her men, and for ten years could afford so much blood; whereas, now laid low, she only shows her ancient ruins; and instead of her wealth she points at

the tomb of her ancestors. Sparta was famed ; great Mycenæ flourished ; so, too, the citadel of Cecrops, and that of Amphion. Now Sparta is a contemptible spot ; lofty Mycenæ is laid low. What now is Thebes, the city of Œdipus, but a mere story ? What remains of Athens, the city of Pandion, but its name ?" The foregoing is historically certain proof that the cities mentioned encountered a great disaster during their early existence.


In the Mediterranean Sea the ancient beaches and terraces of many islands testify to a former period of upheaval. Along the coasts of Syria and Palestine similar evidence exists, as well as that of the Egyptian coast, though at present the land is known to be gradually subsiding.

Sea shells, identical with those at present existing in the Mediterranean Sea, have been found inland in the deserts of Northern Africa, as well as water-worn rocks and beds of salt, indicating the presence of a former inland sea. In the Algerian Desert species of existing shells have been found at a height of 900 feet upon the hills, showing that the land had been upheaved during a recent period.

The change of level which occurred with the last Glacial event resulted in the present distribution of land and water on the globe ; and many of the ancient cities which yet remain escaped destruction by an elevation of the land on which they were built, while others, less fortunate, were submerged by the encroaching waters of the surrounding sea.

CHAPTER XVII.

THE MOUND-BUILDERS.

 CLOUD of mystery enshrouds the name of this ancient race. Silent volumes of knowledge lie hidden in the history of this wonderful people. Long before the Red Indian set foot in America a highly-civilized and industrious people inhabited the central part of the continent, from the Gulf of Mexico on the south to the Red River on the north, and along the north shore of the River St. Lawrence, in Canada, and as far as the Alleghanies and the State of New York on the east. After a comparatively brief stay they suddenly and mysteriously disappeared, leaving behind their elaborately-made implements, wonderful enclosures, and vast structural mounds, from which their name has been derived, as an unwritten record of the former character and civilization of this strange people. The remains of their habitations, tombs and temples are found over broad areas, in the rich and fertile valleys, or occasionally elevated on high commanding positions, and spread continuously over the western, and some of the eastern, parts of North America, up into north-western Canada, and around the neighborhood of Lake Superior. The number and immensity of these structures, the geometrical skill with which

they have been constructed, the different mining implements, relics of war and the chase, and other evidences of civilization, bear witness to the existence of an industrious and numerous race, emerged from the ranks of barbarism, and acquainted with many of the arts of civilization. Their principal labor took the form of gigantic earthworks, such as mounds of various sizes, and walls of earth and stone, ranging in height from three to thirty feet, and enclosing areas from ten to three or four hundred acres. Some of these structures are perfectly round, while in others a resemblance has been traced to birds, reptiles, quadrupeds, etc. In the mounds have been found sacrificial altars, on which rested human skulls, with quantities of charcoal, pottery and other relics. Stone carvings of human figures in kneeling attitudes, copper instruments, spear and arrow heads of flint, drills, pipes and decorated ornaments of various descriptions and beautiful workmanship, have been found in great quantities. A long chain of mounds extends for miles diagonally across the State of Ohio, and on the prairies and valleys of the West they are almost innumerable. In Ohio alone the number of mounds, including the different enclosures, is estimated at about 13,000. They range in size from a few feet in height, with a proportionate base, to a height of eighty or ninety feet; while the bases of others extend over an area of several acres. Some are scattered far and wide, while others are located in groups. The material of which they are composed, though mainly of earth, in many instances

bears evidence of transportation from afar, and is of an entirely different nature from the soil by which they are surrounded. They appear to have been formed with the utmost order and regularity, there apparently being no confusion or random means guiding their construction. From the regular nature of their position and contents they have been found capable of classification, and are now known individually as sacrificial or temple mounds, sepulchral or burial mounds, symbolic mounds, signal mounds and indefinite mounds. Besides these there are terraces or graded ways, and long walls or breastworks, ranging from five to twenty feet high, known as enclosures.

The sacrificial or temple mounds, as their name indicates, were the sacred enclosures of these ancient people, within and around the walls of which the temple mounds were raised, as shown by the nature of their contents. The remains of sacrificial altars have been found in all of these enclosures, on which a fire was apparently kept perpetually burning, as evidenced by the layers of ashes, charcoal and other burnt relics by which they were surrounded. Heaps of burnt human bones, and the presence of their skulls on the altars, plainly indicate an idolatrous form of worship, in which human beings were offered in sacrifice. Most of the enclosures of these ancient temples have their openings facing the east, from which it has been inferred that the Mound-Builders were sun-worshippers, and thus located their altars to receive the first rays of the rising sun. On exploration many of the altars

have been found covered with successive layers of drift material, consisting of sand and gravel, to a depth of three or four feet.

The sepulchral mounds were the vaults or burial places of the Mound-Builders. They are of various sizes—some large, some small, some singly, others in small clusters or scattered over the surrounding country; while other burial places of great extent lie without the enclosures, with nothing to mark or indicate their nature whatever. Within the base of the sepulchral mounds vaults have been found of unhewn logs, containing human skeletons in an advanced state of decay, together with ornaments of mica, bracelets of copper, carvings of stone and beads of shells. Occasionally a large mound contains only one, or, perhaps, two skeletons. Others have been found containing several, grouped in a sitting posture.

The symbolic mounds are long ridges of earth, four or five feet high and twenty or thirty feet wide at the base. Their outlines appear to resemble the figures of different animals, such as the elephant, mastodon, alligator, serpent, beaver and tortoise. Within these structures, also, altars have been found, and other evidences of worship, from which it has been assumed that the traced outlines were those of animals held sacred by this ancient and idolatrous people.

The signal mounds were elevated stations, generally located in commanding positions, on which it is supposed a watch was constantly kept. A regular line of communication could be held between the different

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stations by means of signals. A fire burned on one of these elevations could be seen across the plains for miles, where it could be repeated by the watchman there, and flashed in another direction, and so on from one mound to another, so that in a comparatively short time the whole population could be aroused and warned of any impending danger.

Of the indefinite mounds comparatively little is known. They are supposed to be the uncompleted work of the Mound-Builders. They are scattered in great numbers over the country, and owing to their incomplete nature cannot be properly classified.

Among the many works attributed to the Mound-Builders is the well-known enclosure known as "Fort Ancient," situated on the east bank of the Miami River, in Ohio. The great fortress stands on an elevation 230 feet above the river, on either side of which a deep ravine extends. The whole is encircled by a wall, five miles in length, ranging from five to twenty feet high. In this there are numerous openings, protected by mounds or inner walls. Two large mounds stand at no great distance from the fortification, from which two walls run parallel for a considerable length, where they unite and enclose another mound. The whole bears every appearance of an immense stronghold occupying a very commanding position.

In Illinois the truncated pyramidal mound of Calokios, according to Lubbock, is 700 feet long, 500 feet wide and 90 feet high, its estimated volume being 20,000,000 cubic feet.

In the Mississippi valley, between Alton and East St. Louis, the great platform mound of Cohokia rises up in the form of a parallelogram, over 100 feet high, its sides being respectively 700 and 500 feet in length. On its top is a platform 200 feet wide, and it is supposed to contain in cubic feet about one-fourth that of the great pyramid of Ghizeh. Above this rises a conical mound ten feet in height, in which were found implements of stone, funeral vases and human remains. The mound itself is surrounded by about two hundred others of various sizes and dimensions.

Grave Creek mound, in West Virginia, is estimated to be equivalent in size to the third pyramid of Egypt. It is 70 feet in height and about 900 feet in circumference. When this mound was first discovered trees supposed to be from 300 to 500 years old grew on its summit. On exploration two vaults were found within, one at the base being twelve feet long, eight feet wide, and seven feet deep. The logs of which this vault was formed were all decayed and covered with loose, unhewn stone. Two skeletons were found enclosed, one surrounded with shell beads and other ornaments, while the other had none. The upper vault, which was of a similar nature, contained a skeleton decorated with shell beads, copper rings and pieces of mica.

The great serpent mound, in Adams County, Ohio, is represented with an open mouth, between the jaws of which there is an oval mound four feet in height, the diameter of which is 160 feet in its thickest part.

The body is formed of a curved wall four or five feet in height, and the tail is rolled in a spiral coil. The entire length of the mound is about 1,000 feet.

In the Scioto valley, within a vast enclosure, having regular gateways and approaches, a number of squares are found measuring exactly 1,080 feet.

According to Messrs. Squier and Davis some earth-works of the Mound-Builders measure not less than 550,000 cubic metres, from which it is calculated that four of them would exceed in bulk the largest of the Egyptian pyramids, which is estimated to contain 2,000,000 cubic metres.

The State of Ohio appears to have been the headquarters of the Mound-Builders, they having had great settlements at Cincinnati, Portsmouth, Marietta, Xenia, Springfield, Dayton, Hamilton, Oxford, Miamisburg, Mound City, Eaton, Athens and other places.

Enormous quantities of implements and relics of this ancient race have been collected from the mounds. Whole armories of stone and flint weapons of war and the chase, axes, hatchets, knives, chisels, gouges, pottery of all descriptions, terra-cotta figures, pipes, mortars, pestles, ornaments, coins and articles of bone have been found in abundance. Galena, and instruments of obsidian, a dark, transparent mineral, exceedingly hard, of which none is found in the neighborhood, and which was probably brought from the Rocky Mountains, have been discovered, together with copper ornaments plated with gold, and rings of meteoric iron. Some of the altars have been covered

with a thick layer of opaque mica. In addition to the above there are remains of coarse cloth and other articles of clothing, indicating the existence of a peaceable, industrious and numerous race. That these people had a tolerable acquaintance with the nature of metals and their use is evident from the quantity of broken minerals and the various mining implements left behind. In the copper regions of Lake Superior and other mining districts numerous excavations of great extent have been found, from twenty to sixty feet deep under the surface, containing stone hammers, mauls, copper chisels and other implements used for mining and excavating purposes. Ancient shafts have been found in pits in Minnesota, where excavations have been made as deep as sixty feet through the solid rock, and extending over a broad area of several miles. Detached blocks of copper of various dimensions have been discovered some distance from the place of excavation, together with the implements and tools used in dislodging them, and oaken beams required for their elevation to the surface.

All these works and relics appear to have been suddenly abandoned, and never again claimed by their former owners. Their tools, hammers and mauls lay in undisturbed positions in the mines just as the workmen left them one eventful evening many centuries ago, and for which they never after returned.

The antiquity of the Mound-Builders is generally estimated at about 2,000 years. This conclusion has been arrived at by various geological considerations

and the very decayed condition of the bones found in the mounds. On exposure to the atmosphere the skeletons of the Mound-Builders at once show signs of disintegration, some having crumbled to dust. Skeletons of one-half the estimated age are known to have remained in a comparatively thorough state of preservation under as favorable conditions. The oldest known Indian remains are remarkably well preserved in comparison with those of the Mound-Builders. For this reason alone their great antiquity can be ascribed. But there is other evidence by which a similar conclusion is arrived at. Some of the mounds are covered with a growth of forest trees, many of which have attained a great age. The ages of some of the trees have been placed at about 700 or 800 years, as attested by the number of their concentric rings of annual growth. Beneath the surface evidence of former forests exist in many places where the ancient trees abound, showing that the mounds were entirely deserted before the first vegetation obtained a foothold. This would place the first growth of the previous forests at about fifteen or sixteen hundred years ago.

But who were these strange people? and what became of them? These are questions which have never been definitely answered, though many efforts have been made to solve their identification. Some have regarded them as the earliest Indian tribes; but this idea has been disposed of by a comparison of the crania of the two, which shows that the Mound-

Builders differed essentially from the Indians in the elevation and breadth of the frontal bone, and were their intellectual superiors in every respect. That they were in no way connected with the roaming Indians of the present day is quite certain, for the latter have never been known to lead other than a nomadic life in the past; and they could hardly have gravitated into their present state of degeneracy in a comparatively short period of time without retaining some evidence of their former greatness. There is every indication that the Mound-Builders emigrated from the south, where a far higher degree of civilization then existed than that manifested by themselves. In California, Mexico, Central and South America abound the most magnificent antiquities and remains of a perfect civilization. Great pyramidal mounds and terraces, remains of gorgeous palaces adorned with sculptures of the most elaborate description, altars, paintings, ornaments and undecipherable hieroglyphic tablets are found in great numbers scattered throughout the country, and in the depths of the tropical forests. It has been learned that as the comparatively rude works of the Mound-Builders approach the southern localities they appear to partake of a higher character, resembling the more advanced works with which they seem to approximate. Among the many races who inhabited tropical America during the zenith of its former civilization were the Alleghans and the Toltecs. These races, together with several others, were undoubtedly conquered by the Aztecs, a highly

civilized people who inhabited Mexico previous to the time of the Spanish invasion under Cortez. Now, the crania of the Mound-Builders have been found identical with those of the Toltecs, who, in turn, it is known, resembled the Alleghans, with whom they appear to have been intimately connected. This fact alone would not be sufficient to demonstrate the identity of the Mound-Builders, nor to explain their sudden and mysterious disappearance. From the historical records of these ancient people, combined with the above fact, together with traditionary accounts of their former existing condition, enough can be gleaned to establish an identity between the two. The following applicable narrative is recorded in the third volume of Bancroft's "Native Races" (p. 89): "The natives in the vicinity of Lake Tahoe ascribe its origin to a great natural convulsion. There was a time, they say, when their tribe possessed the whole earth, and were strong, numerous and rich; but a day came in which a people rose up stronger than they, and defeated and enslaved them. Afterward the Great Spirit sent an immense wave across the continent from the sea, and this wave engulfed the oppressors and oppressed, all but a very small remnant. Then the task-masters made the remaining people raise up a great temple, so that they of the ruling caste should have a refuge in case of another flood; and on the top of this temple they worshipped a column of perpetual fire. Half a moon had not elapsed, however, before the earth was again troubled, this time with strong convulsions and thunderings,

upon which the masters took refuge in their great tower, closing the people out. The poor slaves fled to the Humboldt River, and getting into canoes paddled for life from the awful sight behind them; for the land was tossing like a troubled sea, and casting up fire, smoke and ashes. The flames went up to the very heavens, and melted many stars, so that they rained down in molten metal upon the earth, forming the ore that white men seek. The Sierra was mounded up from the bosom of the earth; while the place where the great fort stood sank, leaving only the dome on the top exposed above the waters of Lake Tahoe. The inmates of the temple tower clung to this dome to save themselves from drowning; but the Great Spirit walked upon the waters in his wrath, and took the oppressors one by one like pebbles, and threw them far into the recesses of a great cavern, called to this day the Spirit Lodge, where the waters shut them in."

From this account alone may be learned the identity, history and doom of the long-lost Mound-Builders. They were evidently the ancient Alleghans, in subjection to the Toltecs, who were in turn conquered and subdued by the Aztecs, a far more powerful race. While in bondage they were suddenly surprised and nearly exterminated by the first Drift catastrophe, caused by the standing still of the sun at the command of Joshua. When the waters had retreated, and the temperature of the tropics had become colder owing to the great change of climate which necessarily followed,

many of the remnant emigrated northward into the warmer regions. After that terrible event it was but natural that these people should dread the occurrence of a similar catastrophe. Taking possession of the great ridges and reefs of drift material lying over the face of the country, the conquerors soon conceived the idea of making preparations for any occurrence of a similar nature. The captives, still in bondage, were set to work, and the drift material was utilized in the vast mounds and enclosures which still remain as a lasting memorial of their former labors, and which were evidently prepared with one object in view—a place of refuge in which they might escape in case of a flood.

No adequate idea can be formed of the suffering which must have been endured by the escaping remnant of these people during the dreadful calamity by which they were originally overtaken. The greatest mining disasters, railway or steamboat horrors, of modern times, pale into insignificance in comparison with that awful event. The poor victims can be imagined fleeing in the darkness to the caves and caverns in the mountains, seeking a place of shelter from the blinding, fiery cyclone of stones, gravel and hail which swept the border-land of that great flood. But many escaped the raging waters only to be engulfed in the torrents of molten lava which oozed from fissures in the mountains and flowed over the country for thousands of miles. The feelings of horror and despair by which they must have been overcome can be better

imagined than described, as they patiently waited in the total darkness for the coming of the sun, which they never more expected to shine upon them. And as the day gradually wore away, and the earth still tossed and heaved and no sun appeared, the intensity of their horror must have greatly increased. Strong men groping their way in the darkness in search of their loved ones, and children and helpless babes crying for help from those who would never see them again, must have added to the intensity of the situation. Again, their feelings of joy and delight must have known no bounds when, bruised, burned, torn, and famished with hunger, they once more caught a glimpse of the sun peering through the thick fogs and smoke in which they were enveloped. No wonder the sun was an object of adoration by this ancient people. As they waited and watched in all directions a welcome sight must have met their eyes when the first streak of dawn gleamed over the eastern horizon, and the sun gradually rose high up into the heavens. The details are given by Abbé Brasseur de Bourbourg in Tylor's "Early History of Mankind":—"Now, behold, our ancients and our fathers were made lords, and had their dawn. Behold, we will relate also the rising of the sun, the moon and the stars! Great was their joy when they saw the morning star, which came out first, with its resplendent face, before the sun. At last the sun itself began to come forth; the animals, small and great, were in joy; they rose from the water courses and ravines and stood on the mountain tops, with their

heads towards where the sun was coming. An innumerable crowd of people were there, and the dawn cast light on all these people at once. At last the face of the ground was dried by the sun; like a man the sun showed himself, and his presence warmed and dried the surface of the ground. Before the sun appeared, muddy and wet was the surface of the ground, and it was then only the sun rose like a man. But his heat had no strength, and he did but show himself when he rose; he only remained like" (an image in) "a mirror, and *it is not indeed the same sun that appears now*, they say in their stories."

The temporary change of climate which then occurred is here referred to. As the absence and reappearance of the sun were the most marked features of the catastrophe, it is but natural to suppose that an idolatrous people would attribute the cause of the disturbance to that luminary. The position of their sacred enclosures, looking to the east, and so constructed that its rising rays would fall upon the altars, is sufficient to indicate that they worshipped the sun, and in the desperation of their devotion offered up human sacrifices. The watch towers of the signal mounds show that a look-out was constantly kept in order that the inhabitants might be warned of the approach of the dreaded flood. But one eventful night about 2,600 years ago the beacons of the watchful sentries probably flashed their lurid signals in vain, for the great billows of the second Drift catastrophe rolled over the continent from an unexpected direction, swallow-

ing up their puny Babels and sweeping their builders out of existence. So suddenly did it come upon them that no preparations appear to have been made for escape. The skulls still remain undisturbed on the altars, and the tools and implements of the workmen lie in the mines and other places, just as they were deposited one tropical evening when the sun slowly sank in the western heavens, never more to be seen or worshipped by those ancient and highly-civilized people.

Over the North Pole the waves rolled down into Siberia, engulfing all within their reach. The fleeing natives who were not overtaken found an escape eastward along the peninsula of Alaska, and from thence spread south and over the North American continent. And this is undoubtedly where the Red Indian came from, and how and when he first set foot on the great plains of North America, after the disappearance of that ancient and wonderful people—the long-lost Mound-Builders.

CHAPTER XVIII.

THE SUN.

“The spacious firmament on high,
With all the blue ethereal sky,
And spangled heavens a shining frame,
Their great Original proclaim.

“Th’ unwearied sun from day to day
Does his Creator’s power display,
And publishes to every land
The work of an Almighty hand.”

—*Addison.*

TERRIBLE and destructive as were the terrestrial disturbances of the Drift epoch, they were but particles of the two stupendous astronomical revolutions that extended to the uttermost limits of the astral universe. Not only the planets but the entire solar system suffered from the effects of these tremendous shocks. When the number as well as the enormous immensity of some of these gigantic orbs is considered it seems almost incredible that any power could ever remove them from their existing positions. That such a labyrinth of worlds could be scattered like a storm of hail for hundreds of thousands of miles, and be again brought back exactly to their former positions, after a lapse of several hundred years, is alone sufficient to excite admiration of the omnipo-

tence of the Creator. That such events actually took place is confirmed by the celestial bodies themselves. Of all the mighty orbs within our solar system the sun appears as the undisputed monarch of all, not so much on account of his immense size as from the vast influence wielded over the whole system.

Though its enormous dimensions may be estimated in figures, their realization is beyond comprehension. It is 880,000 miles in diameter, requiring about twenty-five and one-half days to turn once on its axis. Its estimated weight is placed at 2,154,106,580,000,000,000,000,000 tons, an amount as unintelligible to the imagination as the figures used to express it.

"Perhaps the best means of appreciating so vast a figure," says Guillemin, "is to compare it with the volume of our earth itself, which is about 260,000,000,000 cubic miles. We find, nevertheless, that the volume of the sun is equivalent to 1,273,000 terrestrial globes. The earth is by no means the largest of the planets, since Jupiter, Saturn, Uranus and Neptune are respectively 1,230, 685, 74 and 85 times as voluminous as our planet. But if all the planets known, together with their satellites, were fused together into one globe, we should find that the volume of the sun was still 600 times as great as this agglomerated mass."*

The enormous quantities of light and heat emitted from the sun are equally as incomprehensible as the

* "The Sun," p. 113.

realization of its dimensions. Its light has been estimated by Huggens as comparable to 765,000,000 times that of Sirius, the Dog Star, one of the most conspicuous in the heavens. According to Young the total quantity of sunlight is estimated at equivalent to 1,575,000,000,000,000,000,000,000 candles, and its intensity at the solar surface has been estimated at 190,000 times that of candle flame, 146 times that of a calcium light, 3.4 times that of an electric arc, and 5,300 times that of molten incandescent metal in a Bessemer converter.

By a telescopic examination the surface of the sun is found to be diversified by occasional spots, or funnel-shaped openings, through which a dark interior is seen. They are mainly observed on either side of the equator, and have been the means of confirming the idea of an axial rotation of that luminary. Frequently the spots are accompanied by a portion more brilliant than the surrounding parts of the disc, upon the internal surface, called *faculæ*, which sometimes assume the form of converging currents, and radiate towards the periphery. In the solar spots two tints of a very apparently different nature are distinguished by astronomers. "One of these tints," says Guillemain, "consists of one or more nuclei, which appear black when compared to the general brightness of the disc; the other is a grey tint surrounding the nucleus or several nuclei, and rather improperly called the *penumbra*. Sometimes, but not often, black spots or nuclei

are seen deprived of a penumbra, and a penumbra is sometimes seen without a nucleus.

“When minutely examined the nuclei are far from possessing the same tint in every part, though their periphery is generally very clearly defined.

“On the dark background certain hollow portions are noticed—cavities of darker tint than the background. . . . The same remark holds good for the penumbrae. It is those portions of their periphery in contact with the brilliant surface of the disc that are of the darkest grey tint; whether it be an effect of contrast or a reality, the difference of tint is, nevertheless, very marked. Besides, the penumbrae are very often striped with lines descending from their external border to the nucleus, as straight lines, sometimes curved, but generally perpendicular to the edges of the penumbra and nucleus. They appear like the beds of a multitude of streams that have furrowed the slopes represented by the penumbra, and are precipitating themselves into the dark gulf of the nucleus.”*

Within the umbra Dawes discovered what might be termed a nucleolus, or a nucleus within the nucleus. “In all spots which are tolerably symmetrical,” he holds, “this umbra will be found to be perforated near its centre by a perfectly black hole, which is to be regarded as the true nucleus.”

The spots sometimes extend over a vast area and attain immense dimensions, many having been visible to the naked eye. In 1799 Sir William Herschel esti-

* “The Sun,” p. 175.

mated the diameter of a spot, which consisted of two parts, at not less than 50,000 miles. In 1828 Pastorff measured another whose area was computed to be about four times the entire surface of the earth. The most extensive of a group observed by Capt. Davis, in 1839, was estimated at 186,000 miles in length, its surface extending about 25,000,000,000 square miles. Another, in 1843, according to Schwäbe, had a length of about 74,816 miles. In 1858 observations were made of a spot more than 143,500 miles broad, or nearly eighteen times the diameter of the earth. It was computed that one hundred such globes would be required to fill up the cavity, its depth being placed at a very moderate calculation. One measured by Newall, in 1859, exceeded seven times the diameter of the earth. Many others of extensive dimensions have been observed, but the foregoing will show the enormous extent to which they sometimes attain.

Regarding the distribution of the spots in latitude, Carrington observed that they generally manifested a tendency to advance towards the equator as the epoch of minimum is approached. After the arrival of that period the spots disappeared.

The duration of sun spots is also extremely variable. Some vanish in a few minutes, while others remain visible for months. During the course of a single transit some are formed and disappear, and others, occasionally of a more permanent nature, remain in sight during the period of the sun's semi-duration, and after an interval of another twelve and a-half days reappear

and again become visible on the disc. In 1779 Sir William Herschel followed a spot for six months. In 1800, while observing a group, his attention being distracted for a moment, it disappeared in an instant, and could not be found again. Similar instances of this kind have also occurred.

Certain spots have exhibited the appearance of cyclonic motion. From observations made by Secchi, Lockyer, Dawes and others, tornadoes of tremendous fury are known to have occurred, in some instances attaining a velocity of 120 miles per second.

On April 13th, 1869, Secchi observed that the whole of a large spot and contiguous neighborhood was surrounded by multitudes of objects resembling leaves of an elongated form, and that a bridge of this structure extended across the spot. "On the following day," Secchi says, "it was in a marvellous condition, full of bridges, arcs and leaves, like the great spot of 1868."*

In 1862 Nasmyth described the sun's surface as covered with an agglomeration of filaments of definite shape and general uniformity of size, presenting the appearance of a thin, flat layer of "willow leaves." They appeared to be scattered over the surface and to cross each other in every imaginable direction, presenting no defined or symmetrical arrangement whatever. Their average length is supposed to be about 1,000 miles and the width about 100 miles. In thickness the layer did not appear very deep, as the darker stratum underneath was rendered visible through the

* Proctor, "The Sun," p. 223.

interstices which occurred between them. It was the infinite number of these occurrences, he held, that gave to the general solar surface its peculiar mottled appearance.

Many astronomers observe no resemblance in these to willow leaves, though there appears to be a general unanimity of opinion that innumerable granulated masses of luminous matter are scattered over the surface of the sun, crossed by numerous light and dark lines. Others see in the granular nodules a resemblance to rice grains; and they have again been supposed to resemble matted chips of straw, lying parallel to each other, constituting what has been called a "thatch-straw" formation. The penumbrae of the solar spots exhibited a somewhat similar structure, with the exception that their pores are much larger than those on the disc. The striated penumbra has been likened to the bottom of a thatched roof, the separate straws lying in the direction of the spot.

Many theories have been advanced as to the origin and nature of the solar spots. "The various conjectures which have been formed on the subject," said Sir William Herschel, "are evident marks of the uncertainty under which we have hitherto labored. The dark spots in the sun, for instance, have been supposed to be solid bodies revolving very near its surface. They have been conjectured to be the smoke of volcanoes or the scum floating upon an ocean of liquid fire. They have also been taken for clouds. They were explained to be opaque masses, swimming in the fluid matter of

the sun; dipping down occasionally. It has been supposed that a fiery liquid surrounded the sun, and that, by its ebbing and flowing, the highest parts of it were occasionally uncovered and appeared under the shape of dark spots; and that by the return of this fiery liquid they were again covered, and in that manner successively assumed different phases. The sun itself has been called a globe of fire, though perhaps metaphorically. The waste it would undergo by a gradual consumption, on the supposition of its being ignited, has been ingeniously calculated. And in the same point of view its immense power of heating the bodies of such comets as draw very near to it has been assigned."*

Many important facts regarding the sun's physical nature have been revealed by the aid of the spectroscope, an instrument by means of which the chemical constituents of matter in the form of vapor or gas are determined. It consists of a prism placed between the object glass of a small telescope and that of another without an eye-piece, through which the light of the object is admitted by means of a narrow slit. The rays falling on the prism are refracted and passed through the object glass of the telescope at the other end. They are thus brought to a focus, and the result observed is the spectrum of the object light admitted through the slit. A continuous spectrum is that in which there is no gap observed in the series of colors, as in the light obtained from a candle or from incandescent iron,

* Proctor, "The Sun," p. 172,

But light passing through a gaseous atmosphere, such as that emanating from the celestial bodies, will give a spectrum crossed by dark lines, showing that the light has been culled by the gases through which it has passed. It is also inferred that the hotter substances of the glowing atmosphere of an incandescent body may produce bright lines, while the dark lines may be attributed to the absorption of light by those of a cooler nature. By means of a spectroscopic analysis the substances which form the various vapors through which the light passes are thus detected and compared with that of others already recognized. The substance known to produce the one is then inferred to exist in the other.

Of the physical constitution of the sun comparatively nothing is definitely known. It is generally believed that the sun is a vast globe of nebulous matter gradually cooling, the effect of gravity upon its mass producing a shrinkage by which its temperature is constantly maintained. In this manner, it is supposed, the solar fires have been kept up for indefinite ages in the past. The enormous quantity of heat emitted from the sun—as estimated by scientists “at one hundred and seventy-six millions of million horse-power, or about 78,000 horse-power for every square metre (a little more than a square yard)—would require a contraction of the solar mass equal to thirty-five metres per annum to maintain its energy.” Thus, it is held, the temperature is gradually decreasing, and in

the distant future will be lowered to such an extent that life on the earth will cease to exist.

This theory requires for its development an indefinite period of time, and assumes that the process has been going on during the millions of years that are supposed to have elapsed in the past since the sun was first originated. But these are only scientific theories, and must not be mistaken for actual facts. It is universally admitted by astronomers that during man's existence upon the earth there is not the slightest evidence of any variation whatever in the amount of solar energy having taken place. As the cause and date of the Glacial period alone is a satisfactory confirmation of the Scriptural age of the world, the above theory, and all others requiring for their bases an indefinite period of time, at once falls to the ground. There is no alternative, then, but to account for the blemishes, or sun spots, by a great catastrophe occurring within the time of man.

From all accounts and observations, then, the sun appears to consist of an opaque nucleus surrounded by an ocean of molten liquid. The whole is enclosed within a brilliant, corrugated, porous crust, in the same manner as the floating film or scum formed on a crucible of melted metal, the liquid and crust constituting what is known as the sun's photosphere, the entire globe being enveloped in a zone of glowing vapor. A spectrum analysis of the sun's atmosphere shows the presence of metallic vapors, thus indicating the existence of mineral substances in the body in a

state of fusion, in all probability, analogous to terrestrial lava.

The rays of light and heat emanating from the solar body present a continuous spectrum, which is an undoubted indication that they proceeded from a more solid substance than gas. The intensity of the light also presents an unexplainable objection to the assumption of a gaseous body. Although the photosphere is surrounded by disturbances of the most violent nature, it has always remained immobile, and presented a perfect, undisturbed appearance, in which no change of level or upheaval has been observed except in the region of spots. This could not possibly be the case if the photosphere were gaseous.

The nucleus, evidently, is a solid globe from which the material requisite to solar energy is derived and maintained. Its constitution may also be of an adamantine nature and the seat of attraction, owing to the influence exerted upon the planetary system.

The idea of a solid nucleus within the body of the sun is now generally abandoned by astronomers, and there is a unanimity of opinion that its interior is mainly of a gaseous nature. The objection to a solid nucleus is met by the unquestioned discovery of Dawes, who found the centre of the umbra perforated by a perfectly black hole, which could not otherwise be if the nucleus were not solid.

The spectroscope reveals the fact that gases of a lower temperature than those in surrounding parts are found in the solar spots. This would certainly favor

the idea of an opaque, solid nucleus, from which, on exposure, a cooler region was formed. The objects known as "willow leaves" appear to be the scum-flakes, such as accumulate on any molten material. "The exceedingly definite shape of these objects," wrote Sir John Herschel, "their exact similarity to one another, and the way in which they lie across and athwart each other (except where they form a sort of bridge across a spot, in which case they seem to affect a common direction, that, namely, of the bridge itself)—all these characters seem quite repugnant to the notion of their being of a vaporous, a cloudy or a fluid nature. Nothing remains but to consider them *as separate and independent sheets, flakes or scales, having some sort of solidity.*"*

The sun spots are great holes or rents in the solar crust, through which, at times, the interior nucleus becomes visible.

The penumbræ forming the sloping sides of the spots are the broken and ragged edges of the crust. It has been observed that the interior border of the penumbra is generally of a brighter appearance than its exterior, the radiating filaments of the penumbra partaking of the same appearance toward their extremities. This is owing to the lower portion of the penumbra being surrounded by molten fluid. It is also shown that the filaments lying partly or wholly down the slope of a spot manifest a tendency to turn upward, and appear elevated above the surrounding medium.

* Proctor, "The Sun," p. 122.

The faculæ are the ruptured elevations or ridges above the rough surface, as shown by Dawes, who saw them projecting beyond the edge of the sun's disc.

The rents or holes in the crust were dragged open by the attractive influence of the planets as they tore themselves away from the sun when it stood still and ceased to revolve in the days of Joshua. In the equatorial spot zones the crust is rent and torn in all directions. These cavities or breaks form immense whirlpools, into which the molten material is drawn to fill up the vacancy. The rent is then temporarily filled up until the spots are again brought under the direct influence of the planets, when they are again torn open by the dragging influence of the planets on the sun's disc. This would account for the eccentricity of the nucleus and penumbra of a spot, by causing the molten currents to flow into and ebb out of the cavity. The appearance of faculæ generally precede the formation of a spot. A dark point or dot is observed increasing in size, and of an irregular form. After it has attained some degree of development the penumbra begins to be seen, and the cavity continues to increase until its full dimensions are attained. The spots diminish *vice versa*. The edges seem less defined, being gradually covered over with the incandescent molten matter, which occasionally exceeds the faculæ in brightness. As it increases the umbra becomes divided by the joining of the flowing extremities of the accumulated matter on the opposite, or even the same, side of the spot. Across these molten streams

float the flakes of scum or granules described as "willow leaves," until the chasm is completely bridged across. It then becomes contracted in size, gradually closes up and disappears. During the process of formation and disappearance of a spot many changes of an irregular and variable form are assumed, some spots suddenly springing into existence, and others disappearing in an instant.

That these cavities exercise an influence on the planets is well known, and there is now an established association between sun spots and the magnetic disturbances which take place on the earth. That the planets also exercise an influence on the solar disc is shown from observations made by Messrs. De La Rue, Stewart and Loewy. They hold that the solar photosphere is materially affected by the conjunction of the planets, and that the sun spots appear to be dragged into the equatorial region of the sun's disc when either of the planets Jupiter or Venus cross the plane of its ecliptic. After the passage from the equatorial plane the spots again spread in the direction of the poles. Such being the case the rents on the crust would be only a natural sequence if the sun stood still and ceased to revolve. The planets would drag the sun or free themselves by tearing away a portion of the disc. The same planetary influence being constantly exercised on the sun-spot zones would again draw open the rents after they had been filled up and assumed the usual level, and permit of their refilling with molten material after the cause of the disturbance had ceased. "The

universe is one great whole," wrote Thomas Dick, "and all its parts, however remote, must be supposed to have a certain relation to one another; and they may produce an influence, however small and imperceptible, on each other at the greatest distances. The remotest star perceptible to the eye may produce a certain physical influence on our globe, though so small and insensible as to be beyond the nicest calculation."*

In addition to the sun spots another peculiar feature common to the sun is the existence of what is known as the *sierra*, or solar prominences. These are rose-colored protuberances which have been observed around the disc of the sun during periodical eclipses of that luminary. They appear in form as flames of rose-colored light, rising sometimes in triangular or peak-shaped masses, or as ragged lines of projections along the solar disc. Their form is variable, and they have been observed isolated and suspended like clouds in the air. They have been compared by Baily to distant Alpine peaks colored and illuminated by the rays of the setting sun. Several small prominences observed by Goldschmidt during the eclipse of 1860 are described as of an irregular form and resembling globules of mother-of-pearl, which rapidly changed to a rose-color and quickly disappeared. "The most imposing, as well as complicated, of the prominences," he observes—"which I will call the chandelier—was grand beyond description. It rose up from the limb, appearing like slender tongues of fire, and of a rose-color; its edges

* "Sidereal Heavens," p. 165.

were purple and transparent, allowing the interior of the prominence to be seen ; in fact, I could see distinctly that this prominence was hollow. Shortly before the end of totality I saw escape from the extremities of these rose-colored and transparent sheaves of light a slight display in the shape of a fan, which gave to the protuberance a real resemblance to a chandelier.”*

These prominences were first observed in 1773 by Vassenius, at Göttenburg, but no satisfactory confirmation of their existence was obtained till the year 1842. Though recognized during the eclipse of that year, and described by a number of the most reliable astronomers of Europe, it was not till 1860 that all doubts were removed and the prominences confirmed as appendages to the sun, and not optical illusions as previously supposed. While apparently seen protruding from round the circumference of the sun's disc, their general distribution is known to extend over the solar surface, many thousands of miles apart.

Respighi observes that the prominences are less frequent and active at the equator than in the higher solar latitudes, while a few observed in the circum-polar regions are comparatively small and undeveloped, and of short duration. Low jets are seen over the sun spots, and prominences are usually seen where there are faculæ, to which they appear to be more closely related than to the spots. Some remain for several days, while others are rapidly developed or

* Proctor, “The Sun,” p. 262.

disappear in a few minutes. A rising jet is usually the first indication of prominence, which, after attaining sometimes an amazing height, gradually sinks back again to the solar surface, many changeable transformations sometimes taking place.

According to Prof. Young "the number of protuberances of considerable magnitude (exceeding 10,000 miles in altitude) visible at any one time on the circumference of the sun is never very great, rarely reaching twenty-five or thirty. Their number, however, varies extremely with the number of sun spots: during the sun-spot minimum in 1878-79 there were not unfrequently occasions when not a single one could be found, though even during those years the more usual number was five or six—some of them of considerable size. The observations of Tacchini and Secchi have shown that their numbers closely followed the march of the sun spots, though never falling quite so low."*

They vary greatly in magnitude also. Secchi estimated the height of one at 300,000 miles. Three or four observed by Prof. Young exceeded an altitude of 150,000 miles. One seen by him on October 7th, 1880, attained the hitherto unprecedented height of 350,000 miles. But these are exceptions. Of 2,767 prominences quoted he says: "1,964 attained an altitude of 40", or 18,000 miles; and it is worthy of note that the smaller ones are so few, only about one-third of the whole; 751, or nearly one-fourth of the whole,

* "The Sun," p. 199.

reached a height of 1', or 28,000 miles. It is only rarely that they reach elevations as great as 100,000 miles."*

Two classes of protuberances have been observed, both differing widely in their form and structure. They are known as eruptive and quiescent prominences, the former generally appearing in the shape of brilliant jets, of various forms, presenting a metallic spectrum, and the latter of a more diffused nature, in form resembling terrestrial clouds. "The protuberances of this class," writes Prof. Young, "are often of enormous magnitude, especially in their horizontal extent (but the highest elevations are attained by those of the eruptive order), and are comparatively permanent, remaining often for hours and days without serious change; near the poles they sometimes persist through a whole solar revolution of twenty-seven days."†

The eruptive prominences usually occur in the neighborhood of a sun spot. They appear to be propelled with an immense velocity, often exceeding 6,000 miles a minute. "Their form and appearance change with great rapidity, so that the motion can almost be seen with the eye—an interval of fifteen or twenty minutes being often sufficient to transform, quite beyond recognition, a mass of these flames 50,000 miles high, and sometimes embracing the whole period of their complete development or disappearance."‡

Surrounding the photosphere is a continuous zone of what appears to be a flickering sheet of scarlet

* "The Sun," p. 202. † *Ib.*, p. 204. ‡ Young, "The Sun," p. 209.

fire, of which the protuberances have been found to be merely an extension, and known as the chromosphere or chromatosphere. A spectroscopic analysis of the chemical constitution of the prominences has shown them to be enormous masses of glowing, gaseous matter, of which hydrogen is a conspicuous element.

The causes which produce these eruptions have never been definitely ascertained. The body of the sun has been supposed to be mainly of a gaseous nature, and on that account it is altogether inconceivable how any power from within could impart such a tremendous velocity as is requisite to attain such an elevation as that ascribed to the prominences. But this objection disappears if the outer part of the photosphere is assumed to be a solid, porous crust. "Kirchoff and Zöllner have maintained that the luminous surface is either liquid or solid."* Respighi "considers that the sharply-defined bases of the eruptive jets *prove* that the eruption takes place through some compact substance forming a species of solar crust."† The cause of the eruptions may be attributed to the up-rush of heated gas propelled by the constant opening and closing of the solar spots. The gaseous matter escaping through the porous crust forms the chromatosphere; that escaping through the temporarily closed sun spots, the eruptive jets; the quiescent prominences, in the shape of filamentary clouds, or plumes, being those issuing through the rents or cracks variously distributed over the solar crust. Secchi notes that

* Proctor, "The Sun," p. 285.

† *Ib.*, p. 313.

the luminosity of the jet prominences is intense, as shown by Proctor, "insomuch that they can be seen through the light clouds into which the sierra breaks up. Their spectrum indicates the presence of many elements besides hydrogen. When they have reached a certain height they cease to grow, and become transformed into exceedingly bright masses, which eventually separate into fiery clouds. The jet prominences last but a short time—rarely an hour, frequently but a few minutes—and they are only to be seen in the neighborhood of the spots. Wherever there are jet prominences there also are faculæ. The plume prominences are distinguished from the jets in not being characterized by any signs of an eruptive origin. They often extend to an enormous height, last longer than the jets, though subject to rapid changes of figure; and lastly, they are distributed indifferently over the sun's surface. 'It would seem,' says Secchi, 'that in jets a part of the photosphere is lifted up, whereas in the case of plumes only the chromosphere is disturbed.' " *

The foregoing plainly indicates that the jet prominences are eruptive emanations from the temporarily-filled sun spots. The uplifting of part of the photosphere, and the presence of other elements in their spectrum besides hydrogen, shows an origination from molten material below the crust of the photosphere. The undisturbed condition of the quiescent eruptions over the solar surface tend to confirm the idea of

* "The Sun," p. 319.

cracks or fissures in the sun's crust. Through its pores, cracks and rents the heated gaseous matter finds an escape, forming the chromatosphere—a complete envelope around the entire circumference of the sun—and causing the many-colored prominences and rose-tinted arcs observed in connection with the solar disc.

Another even more peculiar phenomena than the solar prominences is what is known as the corona, of which no satisfactory explanation is yet known. During a total eclipse of the sun the black disc of the moon is seen surrounded by a luminous halo, from which shoot out in all directions radiant beams and flashing sheets of pearly light, the portion immediately surrounding the sun being of dazzling brilliancy. Through this luminous effulgence the rose-colored prominences of the chromatosphere blaze and shine with the utmost brightness, the whole forming a crown of glory, or what is known at the moment of totality as a “sun-burst.”

The bright inner portion of the corona is generally of a uniform height, surrounding the solar circumference in the form of a ring of glittering, silvery whiteness. This is extended into a luminous expansion of irregular form, presenting every variety of appearance. Dark, narrow beams, or “rifts,” emanating from the body of the sun, radiate through the corona, and extend far into the outer regions of space. Occasionally the rifts take the form of symmetrical curves; and equally as conspicuous are the bright, beaming stream-

ers which shoot forth in a somewhat similar manner. Frequently these are tangential to the sun's surface, and sometimes assume the form of straight, narrow rays, or beams, which also extend to a vast distance. In form the corona generally appears to partake of that of a four-rayed star, varying in shape as the rifts and streams radiate through it.

The coronal beams are seen to extend for more than a million of miles, many times exceeding in height the lofty solar prominences. Occasionally the appearance presented partakes more of the form of a square than round; but this is known to arise from the fact that in the sun-spot zones the corona attains its greatest accumulation, being apparently diminished and less brilliant at the solar poles, and there is also a more undoubted connection between the two than a mere similarity of location.

During the total eclipse of 1867 observations were made by Herr Grosch, of the Santiago Observatory, Chili, in conjunction with Vice-Director Vergaza and Lieut. Vida. After remarking that the corona does not partake of the nature of a solar atmosphere, Herr Grosch observed that "in the direction of its poles its apparent height exceeded that of the moon by only a third of her diameter; in the direction at right angles to this its extent amounted to four-fifths of that diameter. Its light was white, brighter on the moon's limb, and becoming gradually fainter on the other side. This white light was not in the least radiated itself, but it had the appearance of rays pene-

trating through it; or rather, as if rays ran over it, especially in the direction of east and west, forming symmetrical pencils diverging outwards and passing far beyond the boundary of the white light. These rays had a more bluish appearance, and might best be compared to *those produced by a great electro-magnetic light*. Their similarity to these indeed was so striking that under other circumstances I should have taken them for such, shining at a great distance.”*

The corona is evidently an ocean of electricity emanating from the body of the sun itself, being generated on an enormous scale by the friction of the molten liquid of the lower portion of the photosphere against the solid nucleus, in a manner similar to that in which electricity is generated by the friction of a glass cylinder or wheel against a mixture of tin and quicksilver. In the solar-spot zones, where the friction is most extensive, the electrical coronal accumulation is greatest. From the umbra of the open spots, where no friction is taking place, the dark rifts or bars are emitted; and through the cracks, rents and fissures in the crust of the photosphere the radial beams and streamers shoot forth in all directions. It does not necessarily follow that the coronal spectrum and that of an electric spark should be exactly identical, unless the electricity in both instances were generated by the same material, the spectrum depending mainly upon the substance through which the discharge passes. An unknown bright green line crosses the coronal

* Proctor, "The Sun," p. 345.

spectrum, which may have its origin in the solid nucleus, the material of which it is formed being unknown. The electrical repulsion from the solar surface would also account for the clouds of prominence matter which appear to have no direct connection with the chromatosphere, but are seen unaccountably suspended above it.

“That electricity is involved in some way in the production of the coronal light,” Proctor remarks, “may well be believed; and further, it is far from improbable there is some special electrical action in progress above the prominence regions. . . . The sole explanation which seems available is so startling that at first sight many will be disposed to reject it on that account alone. It is this—that a portion of the coronal light is due to the ejection of matter from the sun, and either chiefly or wholly from those bands of the solar surface which we have thus far termed the spot zones.”*

This matter ejected from the sun which forms the corona is, then, simply electricity generated on an enormous scale, and extending beyond the orbits of the planets. From this source the supply is derived which maintains the connection between the surface of the sun and terrestrial magnetism.

* “The Sun,” p. 414.

CHAPTER XIX.

THE MOON.

“Soon as the evening shades prevail
The moon takes up the wondrous tale,
And nightly to the listening earth
Repeats the story of her birth.

“Whilst all the stars that round her burn,
And all the planets in their turn,
Confirm the tidings as they roll,
And spread the truth from pole to pole.”

—Addison.

ROCKY and rugged mountains, extinct volcanoes, precipitous cliffs, yawning chasms and great barren plains, constitute the present characteristics of our satellite. No atmosphere, no water, no life of any kind, is known to exist on its surface. Yet it evidently was not always so. Once this desolate region presented a scene of animation, and was surrounded by the very same elements of which our planet is composed. But all have long since disappeared. The atmosphere has gone, the oceans and rivers are dried up, the volcanoes are inactive, and naught remains but a world of barren rock, the mere skeleton of its former existence. Everywhere it presents traces of violent eruptive action, to which it appears to have been largely subjected

in times past. Not on one occasion only, for there is distinct evidence of a repetition of extraordinary eruptions. The ring-mountains or craters in some places often overlap one another in a manner which conclusively proves that one disturbing cause took place previous to the other. Owing to its smaller size the effects of these disturbances would be of a more destructive nature on the moon than if reproduced on the earth. Between the material comprising the lunar formations and that of the earth there is a universally-accepted identity. Many of the former present a disintegrated and weather-beaten appearance, and are surrounded by *debris*—an undoubted proof of erosion and atmospheric effects in times past. But all is now changed. No life or vegetation is known to exist upon its surface; no plant or any sentient thing. Of the absence of an atmosphere comparable to that surrounding the earth there is every reliable evidence. A familiar test is that afforded in the occultation of a planet or star by the moon's disc. By this means, according to optical laws, the planetary rays would be refracted when the planet apparently came in contact with the limb of the moon. And not only at the actual moment of contact would this be observable, but for a considerable period previous to the occultation. But not the slightest indication of the same has been ever observed. The star is seen to disappear instantly without any perceptible change whatever. Spectroscopic observations also have shown an unchangeable spectrum in the light of the star—an un-

expected result if the sidereal light passed through a lunar atmosphere. As a consequence no water or volatile fluid can possibly exist on the moon, for the reason that its evaporation would form an atmosphere dense enough to be observed.

From observations made of the lunar regions the surface is seen to be covered with various irregularities in the form of elevations and depressions, such as great ranges of mountain formations, peaks, hills, plateaux, mounds and land swells; while on the vast level stretches, or gray plains, are observed what are known as crateriform mountains, classified into walled plains, mountain rings, craters, craterlets, pits and cones. In addition are numerous clefts or rills, together with radiating streaks or rays, and other peculiarities.

The lunar mountain ranges in many instances resemble those of the earth, rising from the highlands occasionally in gigantic peaks varying in altitude from 10,000 to 20,000 feet. Others appear as single cones rising from a broad, extensive base to a height of from 5,000 to 8,000 feet. They are crossed and intersected by deep ravines and numerous valleys and passes, analogous to those of the mountain ranges of the earth.

The more level portions of the lunar disc were supposed to have been formerly seas, and are thus known as *mares*, on which undoubted traces of a former covering of water have been observed. These remain in the form of alluvial deposits and other similar indications of water erosion. "As remarked by Chacornie,

and confirmed by most observers," says Neison, "the surface of the great gray *mares* appears to have been fluid long after the principal formation of the moon had become permanently rigid. This is especially to be noticed in those cases in which the presence of some powerful disintegrative force seems to have broken down into ruins the wall bordering the *mare*, whilst that abutting on the higher land remains intact, and the interior appears to have been filled up by the inrush of fluid material from off the *mare* itself. In many other cases also, on the borders of the *mares*, there are very strong and consistent indications of the originally semi-fluid condition of the *mares*, in the form of filled-up ring-plains, submerged mountains and walled plains, eruptions of matter into valleys, etc.; and there are also indications of the gradual solidification of the *mare* in the shape of less and less plasticity in the intruding matter."*

The numerous craters and crater pits existing upon the moon consist mainly of large and small saucer-shaped elevations, altogether unlike volcanic orifices or craters, and present a flat interior occasionally interspersed with small conical mounds, or sometimes one single mound rising in the centre. The apparently smooth floors of these low-lying spaces resemble a baked mass of plastic mud, by which they are easily distinguished from the true volcanic craters. The walls of the latter class rise abruptly from the surface, and are more precipitous, while their conical aperture is of

* "The Moon," p. 49.

small dimensions. The whole is surrounded by what appears to be volcanic *debris* and ejected matter, similar in appearance to an extinct terrestrial volcano. Between these two lunar formations a marked distinction exists.

According to Neison "the greater craters apparently existing upon the moon yield to close examination with powerful telescopes, and *appear less and less like volcanic orifices or craters*, their enclosing walls lose their regularity of outline and form, and appear as confused masses of mountains, broken by valleys, ravines and depressions, crossed by passes, and surrounded by low plateaux and an irregularly broken surface; whilst the seemingly smooth floors generally appear as diversely interrupted as the envioning surface. These formations are seen more and more in their true character, *not as craters*, but as low-lying spaces surrounded by mountain regions or disturbed highlands."*

The crateriform mountains differ chiefly in size, and are occasionally observed overlapping and encroaching upon each other in a manner indicating the existence of an interval of time between their successive formations—the subsequent disturbance of the larger showing their origin to be of an older date. In addition to these the *mares* are seen to contain long ridges, hills and mounds, and occasionally present in some places an undulating appearance.

An interesting feature peculiar to the lunar forma-

* "The Moon," p. 44.

tions is a class known as clefts or rills. These appear as long, narrow, deep cracks in the moon's surface, which occasionally extend without interruption for a considerable distance, except when abruptly turned aside by an obstruction, and afterwards continuing their onward course as before. Occasionally they entirely surround a crater formation and radiate outwards; but generally they lie in the open levels, without any apparent source or termination. Their magnitude has been estimated by Schmidt at from eighteen to ninety-two miles in length, and varying in breadth from half a mile to a fraction over two miles. They are often observed on the floor of a walled plain; and though the bottoms of the rills appear to be perfectly flat, the sides of many are usually very rugged, presenting an appearance resembling a dried river bed.

A remarkable feature connected with the moon's surface is observed in the great system of rays or streaks which are observed radiating from some of the mountain walls, and occasionally extending to a great distance—sometimes from 100 to 500 miles. They traverse over the plains, mountains, valleys and craters, and all obstructions, without any perceptible change. They are usually straight, but sometimes branched or curved, and often disappear abruptly at the wall of the *mare*, as though they had been enveloped in some surrounding liquid. At other times they gradually disappear on the plains, where they often originate and disappear without any apparent termination whatever.

Many of the mountain formations are observed surrounded by these bright rays or streaks, the principal being Tycho, Copernicus, Kepler, Byrgius, Anaxagoras, Aristarchus, Olbers and others.

The streaks are seen in their greatest clearness at full moon, and can be traced from their originating point onward over mountain ridge and crater, into the valleys and out again, continuing on their course with perfect straightness, seldom being deflected or turned aside by any obstruction. They are usually parallel to each other, and do not appear to have any considerable depth, but are known to extend for a long distance from their origin, one of which has been traced for 1,700 miles. They have also been observed intersecting each other in a manner indicating successive radiations, the earlier streaks being broken at the points of intersection.

"The true nature of these rays and the origin of the ray system," says Neison, "is unknown, though it appears that they are not merely surface elevations, such as the mountain ridges, etc., and Beer and Mädler regard them as perfectly independent of all surface formations, which, however, later observations with more adequate means do not entirely confirm. The most obvious course would appear to be, to connect them with some process of weathering or surface action, but of what nature there does not appear to exist any evidence; and this alone affords no clue to the reason of their radiating from a centre, as shown in the most prominent systems. In some instances they seem con-

nected, not only with very delicate surface irregularities, but with crater systems, as at Gassendi, and near Kepler, Byrgius, and in the south-west; whilst at others they seem dependent on faults or disturbances of the surface. In several formations the rays seem to have been overwhelmed by the surface of the *mare*, almost as if they had disappeared beneath through some irruption of material from the surrounding surface; whilst in one or two cases they have been disturbed by large formations, as Saussure, and in others by craters and craterlets. In several formations that have the appearance of having been filled up by some means by material from the surrounding *mare*, the rays disappear abruptly at the wall. The true solution of the origin of these streaks or rays will probably not be found until their appearance has been made the subject of a thorough investigation, so as to make known the more delicate features they present.”*

The lunar surface presents a peculiar diversity of appearance. The crateriform rings are remarkable for their extraordinary circularity of form. Whether broken or overlapped, large or small, they are wonderfully uniform and numerous. No theory has yet been found to account for their formation, though almost every known cause has been suggested. They have been supposed to have originated by the downfall of meteoric matter at a period when the lunar surface was in a plastic condition, or to have been formerly great lakes existing upon the moon; and

* “The Moon,” p. 78.

again, that they were produced by the contraction of the lunar crust. Nothing, however, but the solution of the causes which produced the disturbance will be found to explain the inexplicable features of the lunar surface. The so-called craters and walled-plains were formed by the centrifugal action of the water when the moon regained its axial motion after it had ceased for nearly a day at the command of Joshua, and the smaller formations when a similar occurrence took place in the days of Hezekiah, whereby the celestial bodies lost their axial motion and were drawn back to their former places by the attraction of the sun, and the shadow on the dial of Ahaz went backward. While the moon with the earth shot away from the sun, the bottoms of the sea were scooped up in long ridges, which were whirled into circular form when their axial motion was regained. The lunar formations find their terrestrial similitude in the coral reefs of the Pacific and Indian Oceans and the mounds and ridges of the Glacial period.

Prof. Huxley thus draws attention to the remarkable similarity existing between them: "If the waters of the ocean could be suddenly drained away we should see the atolls rising from the sea-bed like vast truncated cones, and resembling so many volcanic craters, except that their sides would be steeper than those of an ordinary volcano. In the case of the encircling reefs the cone with the enclosed island would look like Vesuvius, with Monte Nuovo within the old crater of Somma; while, finally, the island with a

fringing reef would have the appearance of an ordinary hill, or mountain, girdled by a vast parapet, within which would lie a shallow moat. And the dry bed of the Pacific might afford grounds for an inhabitant of the moon to speculate upon the extraordinary subterranean activity to which those vast and numerous 'craters' bore witness."*

Of the numerous theories advanced by selenographers to account for the lunar ray system none have been found to satisfactorily explain their strange peculiarities. They are supposed by some to be lava streams; by others, cracks filled with molten matter from the interior, and diverging from a centre where an explosion took place. Their origin has been referred to the fracturing of the lunar crust by the reaction of the moon's interior, and to the effect of direct instead of oblique rays of light. But no explanation has been found to cover some of their remarkable peculiarities, such as an entire disregard of obstructions in their onward march, continuing in an unswerving path to a termination, although radiating from a known source. The great mountain Tycho is remarkable for the system of rays which emanate from a gray border surrounding its crater. They radiate to a great extent in an undeviating course. Directly in the line of a streak emanating from Tycho is a large crater known as Saussure. This formed no obstruction, for the ray has been traced in the bottom of the crater. A correct theory to account

* "Critiques and Addresses," p. 120. "

for the lunar formations must explain the many similar instances of this kind; how the streak in this case rose up the side of the crater and crossed the flat interior, notwithstanding its great depth. There is only one known way by which it could be done, and that is, by floating icebergs, at a time when such existed upon the lunar surface. The streaks or rays are the striæ or furrows plowed in the surface by the advancing ice, and are identical with those formed on the earth during the Glacial period. Of course, this implies the former existence of an atmosphere and a distribution of land and water similar to terrestrial conditions. But it would be contrary to the philosophy of science to suppose that such did not once exist.

Whether a creative or an evolutionary theory is ascribed to the origin of the moon, it cannot possibly be entertained that the direct and immediate result was a dead and barren waste or a world of desolation. Besides, its extinct volcanoes present evidence of having been once in a state of activity. This indicates a degree of terrestrial analogy; and as water is known to be an absolute factor in volcanic disturbance, it must consequently have existed upon the moon. By no other means than moving ice can the ray or streak systems be explained. The radiations down the mountain side from a common centre show the origination of the glaciers. The parallel furrows extending for hundreds of miles, over every elevation and depression, indicate the forward march of the ice, while the inter-

sected streaks, where the striæ cross each other, plainly demonstrate the occurrence of a second similar cause of disturbance. The apparent overwhelming of the streaks by material from the surrounding surface of a *mare*, show where the ice disappeared in the waters of the oceans, while their abrupt cessation at the wall of a formation marks their termination. Although all observations tend to prove the non-existence of water upon the surface of the moon, the indications of its former presence are so apparent that Glacial action has by some been considered evident. "Prof. Frankland believes," says Guillemin—"and his belief rests on a special study of the lunar surface—that our satellite has, like its primary, also passed through a Glacial epoch, and that several, at least, of the valleys, rills and streaks of the lunar surface are not improbably due to glacier action. Notwithstanding the excellent definition of modern telescopes, it could not be expected that other than the most gigantic of the characteristic details of an ancient glacier bed would be rendered visible. What, then, may we expect to see? Under favorable circumstances the terminal moraine of a glacier attains enormous dimensions; and, consequently, of all the marks of a glacier valley this would be the one most likely to be first perceived. Two such terminal moraines, one of them a double one, have appeared to observers to be traceable upon the moon's surface. The first is situated near the termination of the remarkable streak which commences near the base of Tycho, and passing under

the south-eastern wall of Bullialdus, into the ring of which it appears to cut, is gradually lost after passing Lubiniezky. Exactly opposite this last, and extending nearly across the streak in question, are two ridges, forming the arcs of circles whose centres are not coincident, and whose external curvature is toward the north. Beyond the second ridge a talus slopes gradually down northwards to the general level of the lunar surface, the whole presenting an appearance reminding the observer of the concentric moraines of the Rhone glacier. These ridges are visible for the whole period during which that portion of the moon's surface is illuminated; but it is only about the third day after the first quarter, and at the corresponding phase of the waning moon, that the sun's rays, falling nearly horizontally, throw the details of this part of the surface into strong relief, and these appearances suggest this explanation of them. The other ridge answering to a terminal moraine occurs at the northern extremity of that magnificent valley which runs past the eastern edge of Rheita."*

The rills or clefts observed on the lunar surface—at times on the open plain, within a ringed formation, or surrounding a crater and extending for a considerable distance—are gigantic cracks or fractures in a coating of alluvium or clay with which a great portion of the moon's surface appears to be spread. Their rugged sides and perfectly flat bottoms can only be accounted for in this manner. The irregularities in some parts

* "The Heavens," p. 169.

of the lunar surface resemble those formed by dropping pebbles in a smooth mass of plastic mud or mortar. Exposed to the intense heat of the present long lunar day, which is equal to nearly fifteen terrestrial days, the diluvium of the Drift epoch would be instantly baked and dried in a hard mass, the rills and clefts thus originating from its contraction owing to the rapid rate in which the evaporation took place.

The form of the moon has been demonstrated as that of an ellipsoid with three unequal axes, that of the poles being the shortest, the longest lying in the direction of the earth, and the intermediate that in the direction in which the moon moves. The elongation is attributed to the attraction of the earth upon the moon, the latter being slightly drawn out in the line of the earth's attraction. But, according to Neison, "the moon's figure is, independently of surface irregularities, sensibly perfectly spherical; for, although it has been shown from theoretical considerations that it is ellipsoidal in form, owing to a very small elongation towards the earth, and to a still more minute polar compression, these variations are so slight as to be utterly imperceptible. It has indeed been considered by Gussew that the moon may depart sensibly from the form of a sphere; but the evidence in favor of such a supposition, never in any way strong, has become still weaker and entirely inadequate for any purpose."*

A peculiar feature in connection with the motion of

* "The Moon," p. 12,

the moon is the fact that its movements of rotation and revolution exactly correspond. The moon revolves around the earth in a period of twenty-nine and a half days, and completes only one revolution on its axis during the same time. As a consequence, with the exception of a slight libration, only one side of the lunar surface is presented to the earth, the other being forever hid from sight.

It is considered altogether improbable that an exact correspondence between the two motions could have existed during all past time without the slightest variation taking place. If its axial motion of rotation were at any time but slightly increased, the present adjustment of the two motions could not be maintained, and as a result every portion of the moon's surface would in turn be presented to the earth. That the present seeming irregularity originated from the beginning is also doubtful, especially in the face of the violent changes the moon has undergone in the past.

All that now remains of its former conditions is a hollow bomb of barren desolation, on the surface of which no life of any kind could possibly exist. Being deprived, by ejection, of its internal source of heat, water or any volatile fluid remaining on the moon would be speedily evaporated, owing to the vicissitudes of its temperature, which evidently resulted from a change in the velocity of its movements of rotation.

For fifteen days the surface of the moon is exposed to an intolerable degree of heat and light emitted

from the sun, followed by a corresponding period of intense cold and darkness. Under such conditions, without an internal temperature, evaporation on an enormous scale would be a direct result. With the absorption of all fluids from the lunar surface the moon's atmosphere would disappear also. All, therefore, that remains of its former vitality is a world of lifeless, arid rock, its surface torn and shattered by gigantic, yawning fissures, diversified by lofty and extinct volcanoes, immense moraines and ösars, and strewn with huge boulders and glacial debris of enormous magnitude. In this land of utter desolation unbroken silence reigns alone. Out of its lights and shadows the voice of creation is not heard. "Walking in brightness," amid eternal solitude, its desolate ruins are but the wreck of that first time when

"Glowed the firmament

With living sapphires ; Hesperus, that led
The starry host, rode brightest, till the Moon,
Rising in clouded majesty, at length,
Apparent queen, unveiled her peerless light,
And o'er the dark her silver mantle threw."

CHAPTER XX.

THE PLANETS.

“What, though in solemn silence all
Move round the dark terrestrial ball:
What, though no real voice, nor sound,
Amid their radiant orbs be found?

“In Reason’s ear they all rejoice,
And utter forth a glorious voice,
Forever singing as they shine,
‘The hand that made us is divine.’”

—Addison.

NO more striking proof of the wisdom and beneficence of the Creator is afforded than that shown in the heavens on a clear, calm night. A fathomless abyss of incomprehensible depth stretches from infinity to infinity, in which is displayed the gorgeous majesty of the universe in all its grandeur and magnificence. In this broad expanse of ethereal space gigantic orbs of ponderous magnitude roll in their orbits with inconceivable velocity, while golden suns and silvery moons glimmer and sparkle in the dark transparent azure of the starry firmament. The whole is pervaded by a unity of plan, characterized by the greatest mathematical precision, which would be entirely unaccountable for if it were a direct result of chance. But “the heavens declare the glory of God;

and the firmament showeth His handiwork. Day unto day uttereth speech, and night unto night showeth knowledge. There is no speech nor language, where their voice is not heard."*

Among the myriads of celestial bodies the sun and the planets which circle around it form a class known as the solar system. At various distances from the sun eight large planets revolve, accompanied by a number of satellites, together with a numerous family of smaller members known as asteroids or planetoids. The planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. The asteroids revolve in a ring between the orbits of Mars and Jupiter, the four largest of the group being Juno, Ceres, Vesta and Pallas. Of the planets Mercury is the nearest known to the sun, around which it moves in eighty-eight days at a mean distance of 36,000,000 miles. With the exception of the asteroids it is the smallest of the family. Its diameter is given at 2,962 miles—about one-third that of the earth. It revolves once upon its axis in twenty-four hours and five minutes. Owing to its close proximity to the sun, the great ellipticity of its orbit, and its variable brilliancy, no definite indications of its physical condition have been determined. It appears to be enveloped in a seething atmosphere, but does not shine by its own light, its brilliancy being derived from the light of the sun. Its weight is about one twenty-fourth that of the earth, and it has been estimated that if the sun were divided into a million

* Psalm xix. 1-3.

equal parts, one-half of one of them would exceed in weight that of the entire planet. The light and heat derived from the sun is also many times greater at its surface than that received by the earth, and the changes in the planet's temperature occur with great rapidity, the interval between midsummer and winter being only forty-four days. No actual knowledge of its physical condition is known, nor is it a suitable abode for life such as exists on the earth.

The existence of a planet between Mercury and the sun has long been suspected; and though various instances have been recorded of dark bodies resembling planets passing over the sun's disc, no observation has been definitely confirmed. That there is room for an intra-Mercurial planet is generally admitted by astronomers. Leverrier supposed a group of small planets to exist between Mercury and the sun, in order to account for the fact that the perihelion of Mercury moves more rapidly than it should according to the theory of gravitation. But no such group has ever been found. But the intra-Mercurial space, however, is by no means vacant. Surrounding the sun, and extending out beyond the orbit of the earth, appears what resembles a faint circle of light, rising above the horizon shortly after sundown or just before daybreak, on a clear evening in the spring or autumn, known as the zodiacal light. In the tropical regions the light appears equally visible during the whole year, owing to the height of the ecliptic above the horizon. In the temperate regions, where the course of the ecliptic in sum-

mer is close to the horizon, the light becomes extinguished by the atmosphere of the earth. In the tropics it has been observed in the form of a circle, the light of which gradually fades as it recedes from the sun. Its spectrum has been observed by some to be continuous, and by others to consist of a single yellow line, as though arising from glowing incandescent gas. As to the origin of this phenomenon nothing is definitely known. As it is of a mysterious nature it may be accounted for by the explanation that it arises from a cloud-like mass of planetary *debris*—the fragmentary remains of a shattered planet that exploded during the tremendous and awful astronomical cataclysms that have been recorded. Owing to its close proximity to the sun the material of which it is composed is in a constant state of incandescence, the smaller particles being dissipated into glowing gas by the intense heat and the electrical friction of the coronal streamers which penetrate through it. A ring of this kind would also affect the motion of the planet Mercury in a like manner to that of a group of small planets—the cause assigned by the astronomer Leverrier. Of the explosive nature of the planets, assuming them to be of a similar formation to the earth, there can be no doubt. The elements of which the latter is composed are of such a combustible constitution that it is difficult to realize how the earth remained intact and escaped explosion during the Glacial period.

Venus nearly equals the earth in size, its diameter being 7,700 miles. There is every indication of the

existence of an atmosphere surrounding the planet; and this fact, coupled with its intense brilliancy, prevents a close examination of its physical condition.

The earth follows Venus in order of distance from the sun. The conditions under which life exists on its surface are well known. Three essentials for this seem requisite. An internal temperature derived from a molten interior, a fluid atmosphere surrounding the earth, and an external source of heat emitted from the sun. With the absence of the first the earth would rapidly assume the condition of the moon; with no atmosphere life could not exist; and without the latter the earth would be enshrouded in Arctic desolation. Therefore any planet not possessing a combination of these essentials would present an abode unfit for animal life as we know it. The effects of the Glacial period upon the earth have already been described; and as the planets of the solar system were also involved in the disturbances, a similar effect on them must have been the result. As the physical surface of the planets cannot be perfectly scrutinized, mainly on account of their great distance, the general effects produced must escape detection. Some of the planets, however, present remarkable peculiarities, which may probably be attributed to this cause.

A favorite theory of the earth's physical formation is, that it consists of a solid crust enveloping a molten nucleus, and supposed to be gradually undergoing a slow process of cooling, causing a contraction or shrinkage of the crust. By this means, it is held, the various

inequalities on its surface have been produced, such as the mountains, valleys, ridges and depressions by which it is diversified. It is also supposed to account for the numerous volcanic disturbances and earthquakes which occur at various periods. The contracting process is thought to be going on in a manner resembling that in which shrinkage is produced in a shrivelled apple, the wrinkles on its surface being analogous to the elevations and hollows on the face of the earth. This theory can only hold good by assigning to the earth an indefinite age; for it is quite clear that such a process, going on at a slow uniform rate, would be entirely inadequate to produce the numerous and gigantic ups and downs on its surface within a period of 6,000 years, unless under the most violent disturbances. Such a shrinkage has never been definitely known to exist in historical times; and even if it were so the contraction of the crust must have taken place on an enormous scale in order to account for the formation of many of the mountain ranges of the earth. If such were formerly the case the inequalities would still be increasing in the same ratio as in the past, owing to the gradual and uniform nature of the contracting process. But, on the contrary, many of the elevations are being slowly reduced by disintegration and other causes, while the depressions in many instances are being gradually filled up. Besides, the formation of the principal mountain ranges have long since ceased, for their origin and completion can be traced to various geological epochs

in the earth's history. Then the cooling process must have proceeded at a most rapid rate during these periods, and ceased afterwards. Such a movement would not be uniform; and it is inconceivable how one portion of a contracting globe would shrink and another not if the process were still going on at present. During the Glacial epoch the superficial upheavals originated from beneath, the underlying rocks having in many instances been melted and fused by the upward movement of the molten interior. Volcanic eruptions of the most violent nature were also produced by this cause, together with numerous vast rents and fissures in the crust. Subsequent earthquakes and volcanic disturbances have been undoubtedly produced in the same manner, by the upheaval of the crust from beneath, owing to an interior disturbance, and not by the process of gradual cooling. The expansion of steam, generated beneath by the infiltration of water through the shattered crust to the source of heat, is the only theory sufficient to account for many of the upheavals that have taken place in the history of the globe. The numerous geysers and vaporous jets issuing from below the surface bear testimony to the presence of water on a heated interior. Many of the principal volcanoes are located in the neighborhood of deep seas, some of which have been observed to have undergone various changes in level during volcanic eruptions. Though all mountains were not formed by volcanic eruption, any shifting or oscillation of the molten interior would

be amply sufficient to heave upward the various mountains of the globe.

Mars is the first planet outside the earth. Its diameter is estimated at a little more than 4,000 miles. Its axial revolution is performed in twenty-four hours and thirty-seven minutes, and its annual revolution around the sun in 687 days at a mean distance from that body of about 140,000,000 miles. Its density is much less than that of the earth, and a body weighing two pounds on the earth would weigh but one on Mars. Its equator is inclined to the plane of its orbit at an angle of twenty-seven degrees. Mars resembles the earth in many particulars. The equatorial regions present an appearance similar to land and water, while the poles are seen surrounded by a region of brilliant whiteness resembling ice and snow. It appears to be enveloped in an atmosphere similar to that of the earth, in which supposed clouds have been detected. It is accompanied by two tiny moons, known as Phobos and Deimos, the smallest celestial bodies known. The diameter of Phobos, the inner satellite, is estimated at about seven and one-half miles, and its periodic revolution is completed in seven hours and thirty-eight minutes, its velocity being three times swifter than that of the actual rotation of the planet. Its distance from the surface of Mars is about 4,000 miles. The outer satellite is distant over 12,000 miles, and makes one revolution in thirty hours and eighteen minutes. Its diameter is estimated at about six and one-quarter miles.

In 1877 Schiaparelli, of Milan, observed on the face of the planet a curious system of long, straight channels, or "canals," some of which extended for a distance of over 1,000 miles. In width they appeared to be from fifty to sixty miles, and of a remarkably uniform formation. These observations were confirmed in 1879 and 1881, when they were again detected by Burton and others, as well as by Schiaparelli, who found nearly all of the "canals" to be double. More than twenty have been observed; and instead of a single channel they were found to consist of two, parallel to each other, and ranging from 200 to 300 miles apart. As the character of these "canals" is but little known, and the confirmation of their discovery of so recent date, no theory attempting to explain their nature has been presented. As they appear to be superficial markings, and therefore of comparatively modern origin, their formation may safely be attributed to a result of the Glacial period. The winters of the planet Mars are nearly twelve months long, consequently the intensity and vastness of its polar regions during that season must far exceed those of the earth. Its polar inclination is also greater, being twenty-seven degrees. The shock caused to the planet by the standing still of the sun would precipitate the Arctic regions in their entirety with a tremendous force over its surface, not merely striating it, as in the terrestrial shock, but grooving out vast furrows or "canals" of enormous magnitude, such as have been detected and described.

The parallel "canals" indicate a second similar disturbance with like results. When more definite observations of the planet's surface have been obtained other and further traces of Glacial action will probably be discovered.

Next in order of distance are a group of small bodies revolving around the sun between the orbits of the planets Mars and Jupiter. The largest of this group is estimated at about 200 or 300 miles in diameter, and the inclination of their orbits are much greater than those of the major planets. On this account they are sometimes known as the ultra-zodiacal planets. The earliest of these discovered are Ceres, Pallas, Juno and Vesta. All are named from the mythological personages of ancient Greece and Rome. About 268 of the small bodies are known, and new discoveries are occasionally made. Between all the minor planets an intimate relation is observed, and to such an extent "that if their orbits are figured under the form of material rings," according to D'Arrest, "these rings will be found so entangled that it would be possible by means of one among them, taken at hazard, to lift up all the rest." The discovery of the principal of the minor planets arose from a remarkable prediction, arising from a knowledge of what is known as Bode's law—that the interval between the orbits of any two planets is about twice as great as the inferior interval, and only half the superior one. For instance, the space between the earth's orbit and that of Venus is nearly double that between Venus and Mercury ;

and the interval between the orbits of Mars and the earth is nearly twice that between the earth and Venus. In this ratio the distances proceed in order receding from the sun, as represented by the following figures, each of which, with the exception of the second, is double the preceding: 0, 3, 6, 12, 24, 48, 96, 192. By adding the number 4 to each of these numbers the following is obtained: 4, 7, 10, 16, —, 52, 100, 196. Between the interval of the orbits of Mars and Jupiter a break in the scale was observed, the distance being far too great, after which the ratio was again resumed, but it is known to fail with regard to Neptune. This circumstance resulted in a belief that an undiscovered planet might be found between Mars and Jupiter, a surmise afterwards verified to a certain extent by the discovery of four other planetoids. A strange coincidence existing between the mean distance of Pallas and Ceres attracted the attention of the astronomer Olbers, who advanced the remarkable hypothesis that they were fragments of some large planet which had exploded or been shivered to pieces during some astronomical catastrophe in the remote past. Further observations appeared to confirm this theory; but in the absence of definite proof of a catastrophe, and the apparent failure of the supposed fragments to form a general centre of intersection, Olbers' hypothesis gradually died out.

Observations have shown that the mean distances from the sun of the three first planetoids discovered agree closely with the surmise that they were frag-

ments of an exploded planet, and from these the fourth discovered differs also but very little. The paths of those four also pass through two opposite positions, just as an exploded planet would do under ordinary circumstances. But it has been found that the perihelion distance of some is greater than the aphelion of others; and this by quantity so great as to equal the interval between the paths of the planet Mars and the earth. It has been objected, therefore, to the Olbersian theory, that if a planet exploded the greater portion of the fragments could not possibly attain a velocity great enough to propel them beyond the limit in which they would require to move in an ellipse. It is demonstrable that the velocity attained by the fragments would result according to that possessed by the exploded planet and the force generated by the explosion. Consequently the fragments would not deviate beyond the limit of the ellipse in which they would move; for it is known that if the initial velocity be less than a certain value, owing to the effect of the sun's attraction, the course described would be elliptical. The separate fragments would then travel around the sun in the same direction, and cross a common point of intersection where the explosion occurred. This would result as each completed its individual orbit, notwithstanding the great diversity of their periodic revolution. If, again, the force of the explosion were greater than that of the planet's velocity, the orbit would be a hyperbola; and if the velocity were exactly equal then a parabola would be the path described.

Though the first four of the asteroids discovered fulfilled the conditions pertaining to that of an exploded planet, many of them fail to connect at any one point; and the wide variation in the position of their planes and their orbits, and their ovalness, have rendered it inconceivable how such extraordinary conditions could be the result of a planetary explosion. These objections, together with the fact that the asteroids are scattered over a zone 300,000,000 miles wide, formed a convincing argument to which the Olbersian theory naturally succumbed.

But these objections vanish with an explanation of the manner in which the disaster occurred. It is not difficult to conceive of a planet being gradually broken up as it shot across the space occupied by the ring of asteroids, and scattering its flying *debris* at wide intervals until the whole had terminated in a general collapse. Under these conditions the fragments would travel in paths such as they now describe, instead of moving in a general elliptical course as the result of an instantaneous explosion.

With remarkable evidence of astronomical revolutions having occurred the origin of the asteroids may safely be ascribed to the explosion of a planet formerly occupying the orbit between Mars and Jupiter. Most of those small bodies possess a great inclination, and many have been observed of irregular form—facts which undoubtedly tend to confirm the cause and source of their origin.

Jupiter follows next in order, and is known as the

"giant" planet. It is distant from the sun 485,000,000 miles, its bulk being 1,300 times greater than that of the earth, though its weight is only 310 times as heavy. Its diameter is 88,390 miles, and the period of its axial rotation nine days fifty-five hours and twenty-one minutes. It revolves once around the sun in 11 years and 317 days. Jupiter is attended by four moons, which pass through the same phases as those which characterize the earth's satellite. They are known as Io, Europa, Ganymede and Callisto, the inner being 260,000 miles distant from the planet. In point of difference they range nearly as the numbers 6, 9, 15, 27—each successive increase being about double the preceding. They are all larger than the earth's satellite, the diameter of the smallest being 2,099 miles, and that of the largest 3,436 miles.

The physical appearance of the planet is characterized by what is known as "Jupiter's Great Red Spot." It lies midway between the equator and the north pole, and consists of an enormous superficial formation of a dull brick-red color and oblong dimensions, being 29,600 miles in length and 8,300 miles in breadth.

Of the nature and cause of Jupiter's great spot nothing is known, but its origin may be also traced to the Glacial period. A peculiar feature connected with the planet is the vast amount of its polar compression. At the poles a region of comparative flatness exists, and the inclination of its axis is but slightly inclined from perpendicular. Consequently when this planet shot away from its present orbit, at the standing still

of the sun, the force occasioned by its comparatively slight vertical shock was not sufficient to drive the polar accumulation down over the face of the planet. Owing to its vast equatorial protuberance the detrital accumulations of the Drift would be lodged between the north pole and the equator, in the position occupied by the great red spot. Then, during the time the planet receded from the sun without its axial motion the alluvium and detritus of the Drift would assume an oblong form, according to the direction of the flying planet, owing to the enormous quantity of the drift material, its area being over 200,000,000 square miles.

The red color of Jupiter's spot may be attributed to the nature of the underlying rocks on which the drift material rests. In the terrestrial drift the clay varies both in color and composition according to the formation on which it is deposited. Thus it is of a red color over the Old Red Sandstone, fawn-colored over the Silurian rocks, and black over the Carboniferous formation. "Although a large proportion of the boulder deposit, or 'northern drift,' as it sometimes called," remarks Lyell, "is made up of fragments brought from a distance, and which have sometimes travelled many hundreds of miles, the bulk of the mass in each locality consists of the ruins of subjacent or neighboring rocks; *so that it is red in a region of red sandstone, white in chalk country, and gray or black in a district of coal and coal-shale.*"*

Jupiter presents another interesting and inexplicable

* "Elementary Geology," p. 121.

peculiarity. Its disc is seen to be surrounded by a series of bright and dusky belts, parallel to each other and to the equator of the planet. The middle or equatorial belt is of a pearly whiteness, and is followed in the direction of the poles by light and dark alternating streaks or zones of a yellowish or grayish tint. The planet appears to be surrounded by an atmosphere of great depth, and from the many changes and irregularities taking place on its surface is at times the scene of violent storms and cyclones of tremendous nature, occurring continuously for many weeks. The belt zones are observed to undergo many changes. In 1860 a great rift, 10,000 miles long and 500 wide, was observed across one of the zones, where it remained for over three months, gradually increasing in size until it stretched nearly across the disc of the planet, and attained a length of about 100,000 miles. As the rift grew it travelled from the end nearest the equator in the direction of the planet's rotation at the rate of about 150 miles per hour, the zone belt gradually becoming much wider. Similar disturbances constantly occurring on the planet indicate an unknown degree of terrestrial analogy. Jupiter's belts are supposed to be clouds in the planet's atmosphere; but the enormous magnitude of the changes going on suggest an entire distinction from the forces at work in the atmosphere of the earth. An intimate relation between the disturbances arising from the movement of sun spots on the solar surface and the Jovian cyclones has been observed. The movements of the enormous

rifts occurring in the belts of Jupiter correspond with those of the solar spots, both undergoing numerous changes in an apparently similar manner, and travelling with a swifter rotational movement at the equator than at the poles. It has also been observed that one apparent association exists between the period of maxima and minima of sun spots and the disturbances occurring on the planet Jupiter. These disturbances may be explained in a manner similar to the cause of the solar eruptions. The equatorial region of Jupiter's crust has been torn and rent by the effects of the astronomical revolutions of the Glacial epoch. Enormous masses of gaseous vapors are constantly upheaved from the depths below, in like manner, but on a smaller scale, to the eruptions causing the solar prominences. Owing to the great velocity of Jupiter's rotation the vaporous uprush would be left in a trail behind, forming the dusky belts extending along the equatorial regions. The attractive influence of the sun on the planet would tend to drag open the atmosphere surrounding the rents or holes in the Jovian crust in a manner identical with the formation and disappearance of the solar spots. That such a reciprocating action exists between the sun and the planets seems altogether undoubted; and owing to Jupiter's gigantic dimensions it is but reasonable to expect that that planet exerts a great proportion of the influences at work in producing the disturbing process of the sun. As Jupiter is distant 485,000,000 miles from the sun it seems almost absurd that such simultaneous connec-

tion could exist between the two bodies; but when it is considered that the latter is surrounded by an ocean of coronal electricity this difficulty must disappear. The enormous quantity generated, and the velocity with which electricity travels, would be quite sufficient to maintain an immediate communication between the sun and any body existing in the outermost limits of the solar system. That such electric currents or lines exist between the sun and the planets is evidenced by the many meteorological disturbances which have been observed when these currents have been interfered with at the time of perihelion or aphelion, or during the conjunctions of the planets. The fact that spots on Jupiter's equatorial belts have been observed to travel forwards with a velocity greater than the planet exhibits at its poles is indicative of a solar influence independent of the planet's rotation. Carrington has pointed out an equatorial advance equal to 637 miles per hour over a spot situated between that region and the south pole. The time occupied in the revolution of the great red spot is also longer than those of white spots occasionally seen near the equator. The red spot being a physical permanency on the planet, and the belts consisting of eruptions of gaseous matter, explains this apparent difficulty. The movement of the former represents the time of the actual rotation of the planet, while the extra velocity of the latter is imparted by direct electrical solar influence. Owing to Jupiter's vast size the communication existing between him and the sun

would be more readily observed and detected than the relations existing between the latter and the various smaller planets. A similar connection between the atmospheric disturbance of the earth and the occurrence of solar changes has already been noted. When such a phenomenon is known, by actual experience, to occur upon the earth, Jupiter's gigantic size must tend to produce a more intimate relation between himself and the sun, notwithstanding the immense gulf of space which separates them.

Saturn's mean distance from the sun is 881,000,000 miles, and the periodic time of its revolution twenty-nine and a half years. Its equatorial diameter is 73,300 miles, and it completes one revolution on its axis in ten hours and fourteen minutes. It shines with a faint, but remarkably steady, light, free from any star-like scintillation or brilliant glare, such as characterize many of the celestial bodies. It is attended by eight satellites, or moons, which present many variations of appearance, and revolve around the planet in conformity with Kepler's laws and the Newtonian theory of gravitation. Saturn is nearly 1,000 times the bulk of the earth, but its density barely exceeds it by one-eighth, being less than that of water. Certain bright belts and spots mark the surface of the planet, the nature of which has not yet been detected, those on the equatorial region being of a yellowish or golden hue.

In Washington, on December 7th, 1876, Prof. Hall witnessed what appeared to have been an immense

eruption of incandescent matter near the equator of the planet Saturn. It seemed to have burst forth suddenly from the interior, and spread in an easterly direction in the form of long, light streaks, which were apparently carried in the direction of the rotation of the planet. It was also seen by several astronomers, and the time in which it crossed the planet's disc was found to be ten hours and fourteen minutes.

Saturn is surrounded by three broad, thin, concentric rings, narrowly separated from each other, a much wider interval separating the whole ring from the body of the planet. The inner ring is dark in appearance and about 9,000 miles wide. The interval between it and the body of the planet is about 10,000 miles, and is known to be decreasing about twenty-nine miles a year. Then follows an inner bright ring 18,300 miles wide, separated from an outer bright ring 10,000 miles in width by a gap of 1,750 miles. The thickness of the rings has been estimated at about 250 miles.

While intervals between the planet and the dark inner ring is gradually diminishing, the width of the ring is increasing, and there is a possibility that in two or three hundred years it will reach the surface of the planet. The two bright rings are observed to be also undergoing a similar change, the inner of which has greatly increased in width by its approach in the direction of the planet's equator.

In 1665 Huggens discovered the first and largest satellite of Saturn, the eighth and last being first seen

in 1848, in Cambridge, U.S., by the Bonds (father and son), and in Liverpool, England, by Lassell. These are as follows:—

	<i>Distant from the Centre of Saturn.</i>
1. Mimas	119,725 miles.
2. Enceladus	153,630 “
3. Tethys	190,225 “
4. Dione	243,670 “
5. Rhea	340,320 “
—	—
6. Titan	788,915 “
7. Hyperion	954,160 “
—	—
—	—
—	—
8. Japetus	2,292,790 “

It will be seen from the foregoing table that the satellites of Saturn range proportionately in order of distance from the planet, but between the fifth and sixth a gap occurs, similar to that occupied by the ring of asteroids between Mars and Jupiter. Between the seventh and eighth a still greater vacancy is observed, in which there is proportionately room for about three more satellites. It will therefore be safe to assume that Saturn was originally attended by twelve moons, four of which are missing entirely or have never been discovered.

All of Saturn's moons revolve around the planet in regular varying periods of from twenty-two hours to seventy-nine days. During the periodic revolution of the planet many changes and phases are observed, in which the planet is seen to resemble a golden globe surrounded by a brilliant ring, which gradually dis-

appears and resembles a minute streak of light when the edge of the ring is presented to view.

During one-half of the planet's orbital revolution the sun shines on the northern side of the ring, the southern side in turn being illumined during the other half. In time a position is presented in which the light of the sun will shine only on the edge of the ring. The movement of the satellites along this filamentary line has been described by Sir William Herschel as resembling "golden beads on a wire." From the regions of the planet a scene of amazing grandeur would appear. The sky is spanned by the vast luminous arches of the rings stretching from horizon to horizon, on which the shadow of the planet is cast, while the many changes and eclipses of the swift-whirling moons, together with the glittering stars, present a magnificent spectacle of celestial scenery.

Of the nature of Saturn's rings a definite conclusion has not yet been reached. They have been supposed to have been formed by the tail of a comet which had been overcome by the attraction of the planet and forced to circulate around it. Another opinion held them to be solid, having been originally a part of the planet itself, but driven off from its centre by the centrifugal force of its rotation while the planet was in a liquid condition. These portions then became solidified by cooling. Saturn was also thought to have attained at one time enormous dimensions, but afterwards shrunk, the rings being formed of the residue of the older planet.

That the rings are not uniformly solid has been definitely demonstrated, a fatal objection, among many others, being the various temporary divisions which occur in the rings, and which occasionally change in position or disappear altogether. It has been also shown that they could not be fluid and maintain their continuity. The most reliable theory is the one now generally accepted, that the rings are formed of clouds of myriads of invisible meteoroids, too small to be individually detected, and in the case of the inner dusky ring they are not close enough to present the luminous appearance of the brilliant rings. This being the only theory known to account for many peculiarities connected with the rings, their number, size and origin remains to be explained. As before pointed out, according to the proportional relations of the distances existing between the moons of Saturn that planet is entitled to four more satellites. These are missing, and the rings may be accounted for as being formed of the minute fragments of these moons, which have been shattered and shivered to atoms during the astronomical revolutions recorded to have taken place. The inner dark ring, where the meteoroids are far apart, may be considered as formed of the moon missing from the gap between the fifth and sixth satellites. The inner bright ring is about twice the width of the dark one, being composed of the fragments of two of the moons missing from the gap between the seventh and eighth; while the third moon contributed to the formation of the outer bright ring. The dimensions of the rings,

however, would mainly depend upon the size of the exploded satellites. The attraction of the remaining eight moons would be sufficient to produce the temporary divisions at times taking place in the rings, and tend to maintain the intervals existing between them. The motion of the rings being constantly retarded by the atmospheric effects of the planet would result in their continual approach towards its body, and a final collapse upon its surface.

Uranus is about 35,000 miles in diameter, and though its volume is sixty-four times greater than that of the earth, it is only fifteen times as heavy. Its distance from the sun is estimated at 1,771,000,000 miles. Though its velocity is 252 miles per minute, it requires eighty-four years to revolve once around the sun. The period of its axial revolution is unknown. This planet is attended by four moons, the planes of which are inclined ten degrees beyond the pole. As a consequence their motions of revolution are from east to west, being retrograde as compared with those of other planets. To account for this unparalleled peculiarity seems difficult; but as these bodies also shared in the revolutions of the Glacial epoch it is evident that they were then disturbed from their former positions into others, by which their orbits became tipped up to their present inclination. It is altogether improbable that the present motions of these satellites always existed, for, with another exception, no similar cases are yet known.

Neptune is 2,864,000,000 miles distant from the sun,

around which it revolves in about 165 years, travelling with a speed of 200 miles per minute. Its diameter is 35,000 miles, or more than four times that of the earth. A remarkable feature in its history was its discovery by prediction, the various perturbations of the planet Uranus being ascribed to the attraction of an outer planet. This prediction was found correct. Its place was computed with singular exactness, and the long-looked-for planet discovered. Owing to its stupendous distance from the sun its physical appearance is unknown. It is attended by one moon, the plane of which, like those of Uranus, is vertically inclined to that of the planet's equator, showing that the shocks to the solar system extended to a known distance of nearly 3,000,000,000 miles.


With Neptune the outermost of the planets is reached. Though at such an incomprehensible distance from the centre of the solar system the law of gravitation universally pervades. From one unsupported centre light, heat and power are emitted sufficient to supply and control proportionately an infinity of worlds, from the tiny moons of the planet Mars to the enormous orbs that spin and fly with inconceivable velocity in an abyss of space, at a distance too remote to be grasped by the imagination. Beyond the orbit of Neptune lies a vast, unexplored ocean of space, defying the most piercing penetration, while the mind reels and staggers in the attempt to fathom its starry depths. From this incomprehensible void comes the mysterious Voice of Creation speaking of the terrible

majesty of Him who loosed the bands of Orion and guided Arcturus and his sons amid the complex intricacies of that perilous course into which they deviated when "the sun stood still upon Gibeon, and the moon in the valley of Ajalon." "The pillars of heaven tremble and are astonished at His reproof. . . . Lo! these are parts of His ways; but how little a portion is heard of Him? but the thunder of His power who can understand?"*

* Job xxvi. 11, 14.

CHAPTER XXI.

COMETS, METEORS, ETC.

F the nature of the comets comparatively little is definitely known. Suddenly and unexpectedly, from some remote region of the heavens, a comet makes an appearance, rushing impetuously in its course, and after a short time disappears, sometimes for many years, and perhaps forever. Unlike the planets they travel in eccentric orbits, generally in the form of an ellipse, and pass very near to the body of the sun on their return. Occasionally they appear directly to cross the path of another celestial body, or swiftly speeding in that direction threaten to impinge against it or collide with those having a more regular and fixed motion. There is something of a mysterious nature connected with these unknown wanderers that causes them to be received on their approach as unwelcome visitants. There is a universal feeling that they are not natural creations, like the other heavenly bodies, but interlopers of a strange nature, which by some unaccountable means have found their way to our solar system. In times past the terror and dread excited in some places by the announcement that a comet would cross the path of the earth was something astonishing. Persons of weak minds died of fright,

and other incidents and disorders occurred. In 1832 so great was the terror excited in France by the prediction that a comet would cross the earth's path that a certain Parisian professor begged the Academy of Sciences to refute the assertion which had gained popular belief, that a comet would encounter the earth. Why this dread of a comet should be of such a universal nature is difficult of explanation. No feeling of alarm is excited at the movements of any of the planets, some of which are of a wonderful appearance and far more complexity of structure, such as Saturn with his amazing ring system, and Jupiter with his family of moons and terrific tornadoes. But the approach of a comet is the occasion of wonder and excitement. They exist in countless numbers. According to Kepler comets are scattered throughout the heavens as profusely as fishes in the ocean. Of their physical nature little is definitely known. Whence came they? and what are they? are unsolved problems in astronomy.

Comets consist of a nucleus, sometimes of enormous magnitude, accompanied by a luminous train, occasionally spreading over an immense space in the heavens. The former is surrounded by a nebulous haze or envelope, separated from it by a dark interval. The latter presents a transparent appearance, through which stars have occasionally been observed. The train, or tail, generally lies in a direction opposite to the place of the sun, though this is not always the case, comets having been observed with the direction

of the train at right angles, and in various other positions, to that luminary. Often the tails are bifurcated, and sometimes they assume the most fantastic shapes; while others appear as an entire train, and exhibit no signs of a nucleus whatever. They generally cover an immense space, and appear enlarged in proportion as they recede from the head of the comet.

The year 1680 witnessed the appearance of a remarkable comet, on account of its near approach to the sun. Its nucleus was estimated at ten times the size of the moon, its tail extending over a space of seventy degrees. At its perihelion, or the point of its orbit nearest the sun, it approached to within about 146,000 miles from the surface and 584,000 miles from its centre. It appeared to descend almost perpendicularly to the sun, around which it shot with a tremendous velocity, estimated at no less than 1,240,000 miles an hour! As it ascended again its velocity was proportionately retarded in the manner of its former acceleration. The temperature of this comet was estimated by Newton at 2,000 times the heat of red hot iron. Herschel estimated its glare at perihelion as 25,600 times fiercer than that of an equatorial sunshine at noonday, with the sun vertical. At its aphelion, or point in the orbit farthest from the sun, its greatest distance was no less than 13,000,000,000 miles, as shown by Dr. Halley. During its travels it approached within 440,000 miles of the earth. The period in which it completes this vast orbit is supposed to be about 575 years.

Among the celebrated comets was that of 1682, known as Halley's comet, whose return was predicted and verified in about seventy-six years.

Another appeared in 1774 which was remarkable for the changeable nature of its nucleus and train—the former, which had previously been round, appeared oblong in the direction of the tail, and the latter afterwards became bifurcated, or divided into two branches. The diameter of its nucleus was about the same as that of the planet Jupiter, and its train was estimated at about 23,000,000 miles in length.

A comet appeared in 1770 whose orbital revolution was estimated at but five and a half years, but it mysteriously disappeared and has never been seen since.

Schroter's observations of the comet of 1807 gave an estimated diameter of its nucleus at about 4,600 miles, or about the size of the planet Mars, and apparently of considerable density. At certain periods its coma increased and decreased in size, being estimated at about 120,000 miles, and its velocity at 55,557 miles per hour. Its train was divided into two separate branches, one side being convex, while the other appeared concave. The most remarkable feature in connection with the comet was the variation and coruscation of the tail. Within one second streamers shot forth from the expansion of the train to a distance of 4,600,000 miles.

Encke's comet was discovered in 1818, and was also remarkable for the shortness of its periodic revolution,

the time required to complete its orbit being but 1,200 days.

In 1826 Biela's comet was first observed, the period of its revolution being six and three-quarter years. The predicted appearances of the comet were afterwards verified. In 1832 it crossed the plane of the ecliptic a little over a month in advance of the earth, its approach creating great excitement as to the possibility of a collision. In September, 1832, Herschel saw a group of stars of the sixteenth and seventeenth magnitudes through this comet. "Though that group," says Dick, "could have been effaced by the most trifling fog, yet they were visible through a thickness of more than 50,000 miles of cometary matter; and therefore it is supposed scarcely credible that so transparent a material, affording a free passage to the light of such minute stars, could be capable of arresting and reflecting to us the solar rays."*

A comet of remarkable brilliancy and splendor appeared in 1811, being visible to the naked eye for over three months. Herschel gave the greatest length of the train at 1,000,000,000 of miles, and its breadth as nearly 15,000,000. The nucleus appeared to be spherical and to shine by its inherent light. Its nucleus was estimated by Schroter at 50,000 miles in diameter, or nearly six and a half times that of the earth. He was of opinion that this great body was in "all probability chiefly fluid, though its central parts might consist of denser substances, and that there was reason

* "Sidereal Heavens," p. 162.

to believe that it shone with its own native light. The coma was extremely rarefied in comparison with the nucleus, resembling a very faint, whitish light, scattered in separate portions. It was divided into two—one immediately encompassing the nucleus; the other, of a more faint and grayish light, sweeping around it at a distance, and forming the double tail which the comet presented. The train, or head veil, as he terms it, swept around the nucleus at a distance equal to its breadth, and appeared as unconnected as the ring of Saturn with its body, and which sometimes appeared darker than the open sky. The diameter of this exterior part of the head was $34' 15''$, or about 947,000 miles, which is larger than the diameter of the sun, and which he thinks must have formed a hollow cone around the nucleus, and which he thought indicated a force of a repulsive nature residing in the nucleus. Between the 4th and 6th of December a great revolution took place; the rarefied nebulous matter, which had for three months been so unusually repelled from the nucleus on every side to a distance of about one-fifth of the diameter of the head, or 190,000 miles, was again attracted to it, affording an incontrovertible proof of physical action upon a great scale, arising, doubtless, from the same causes which produce the other phenomena of nature. The double tail of this comet was exceedingly faint compared with the nucleus and coma. . . . Coruscation similar to that which appeared in the tail of the comet of 1807 was likewise perceived, particularly on October 16th, when

a small tail instantaneously appeared, then vanished and reappeared, which was in length equal to three times the diameter of the comet's head, or 2,373,000 miles. Other displays of the same kind took place on the 7th of November and the 18th of December."* The periodic revolution of this comet has been computed at over 3,000 years; according to Bessel at 3,383 years.

Donati's comet of 1858 was remarkable for the many peculiar phases and transformations it presented. The nucleus was observed surrounded by three distinct envelopes, connected with each other by radial streaks of light issuing from different parts of the nucleus. Shortly after their appearance a new tail was seen, in addition to the primary one, lying in a direction exactly away from the sun. This was followed by another of a fainter appearance, and the nucleus at perihelion presented indications of the most violent and angry excitement.

Respecting the actual structure of comets nothing definite has been ascertained, save that of their apparently gaseous nature; but that there is an undoubted connection between meteors and comets appears to be well established. Sir John Herschel's observations of the comet of 1862 confirmed the fact that recognized meteor-systems are found to follow in the track of known comets.

Meteors are known to consist of minute bodies clustered together in zones or rings, and ranging in

* "Sidereal Heavens," p. 152.

size from a small pebble to the most gigantic boulder. Those which travel around the sun in orbits lying in the course of the earth's path periodically come in contact with it. They move with enormous velocity through space; but in plunging into the atmosphere surrounding the earth their speed becomes suddenly checked, resulting in the ignition of the meteors, which then appear visible as shooting stars. Owing to the intensity of the heat generated by the friction the smaller bodies become dissolved into a streak of glowing vapor in their course through the air; but the larger ones occasionally reach the earth in the form of aerolites, or meteoric stones. These have been found similar in their elementary constitution to the igneous rocks existing in the crust of the earth, and possessing nearly the same density, from which it is inferred that aerolites have had an origin in common with that of the earth. Meteoric fireballs of great magnitude are known as bolides. It is estimated that the heat of a meteor generated by atmospheric resistance would exceed that of a rifle-bullet 10,000 times.

In November, 1869, a meteor flashed across the south of England and disappeared in the sea off the coast of Cornwall. Its course was ascertained to be 170 miles in length, which it traversed in five seconds, leaving behind a luminous streak fifty miles long and four wide, which remained visible for fully five minutes.

During the course of the earth's orbit two recognized rings of meteors are intersected, giving rise to the annual meteoric displays of August and November.

The revolutionary time of the August meteors is supposed to be about one hundred and five years, and that of the latter about thirty-three and a quarter years. During these periods the earth encounters an enormous swarm of meteors, ranging in weight from an ounce to many tons, the whole travelling in the path of recognized comets.

Meteors belong to the same class of matter as aerolites, or meteoric stones, which occasionally fall to the earth, and which have yielded the nature of their composition to chemical and microscopical analysis. The result of such analysis shows that the material of aerolites had been originally in a state of fusion, in the form of small, detached, melted globules, the formation of which cannot be satisfactorily explained. It is supposed, however, that there is a connection between them and the constituent elements of which the sun is composed. "This would clearly suggest," says Proctor, "that these meteoric masses were originally expelled either from the sun or from one of his fellow suns, the stars, or else that we must look back to some long-lost epoch in the history of the universe when a true chaos prevailed, regarding meteorites as the fragments left from the time of chaos. Let us see what the chemical analysis of meteorites may suggest as the more probable of these views. The chemical evidence is singularly decisive. Prof. Graham, the late Master of the Mint, and one of the greatest chemists of our day, examined the iron of an aerolite called the Lenarto meteor, from the place where it fell. He

tested it with special reference to the quantity of hydrogen contained in it; for hydrogen and other gases can be occluded, as it is called, or, as it were, closed in, within the substance of iron. Now, observe what he says about the iron of this meteor:—‘It has been found difficult to impregnate malleable iron with more than an equal volume of hydrogen under the pressure of our atmosphere. Now, the meteoric iron (this Lenarto iron is remarkably pure and malleable) gave up about three times that amount without being fully exhausted. The inference is that the meteorite had been extracted from a dense atmosphere of hydrogen gas, for which we must look beyond the light cometary matter floating about within the limits of our solar system. . . . Hydrogen has been recognized by the spectrum analysis of the light of the fixed stars by Messrs. Huggins and Miller. The same gas constitutes, according to the wide researches of Father Secchi, the principal element of a numerous class of stars, of which Alpha Lyræ (the leading brilliant of the Lyre) is the type. The iron of Lenarto has no doubt come from such an atmosphere, in which hydrogen greatly prevailed. *This meteorite may be looked upon as holding imprisoned within it, and bearing to us, the hydrogen of the stars.*’”*

From the foregoing the remarkable conclusion to be deduced is, that meteor systems and comets are the remains of thousands of shattered worlds and erupted ejections from others more fortunate in escaping de-

* “Expanse of Heaven,” p. 147.

struction during the astronomical catastrophes which occurred in the days of Jôshua and Hezekiah. The relations existing between comets and meteors, by which countless myriads of the latter follow in the paths of comets, may thus be accounted for. While many comets of the smaller class have undoubtedly been ejected from the celestial bodies, others are in whole the entire molten interior of exploded ones. The comets ejected from other bodies would move in elliptical orbits, and if not expelled from the solar system by the intensity of the expulsive force would again return to the place of their origination. The comets of 1843, 1880 and 1882 almost grazed the sun in the course of their perihelion, from which it is evident they originated. The enormous sun-spot cavities were no doubt the birthplace of these comets. On the other hand, the orbits of short period comets, which do not pass close to the sun, have had a planetary origination. Proctor points out that comets of this class are intimately associated with the greater planets of the solar system. Jupiter, Saturn, Uranus and Neptune have each their related comets hovering about their paths, and apparently under their control, from which it must be inferred they were originally ejected; hence the low density of the greater planets. The motions of this class of comets, which correspond with their related planets, are generally forward and with little inclination to that of the planetary level, and also point to an intimate relation between them.

The relations existing between comets and meteors,

by which countless numbers of meteoric bodies follow in the same orbit, may be accounted for by an explanation of the origin of meteors. The broken and fragmentary crust of which the meteors are formed would then travel behind in the same direction as that of the comet, as is generally known to be the case. The transparency of the nucleus, through which stars have been observed, would result when viewed at an enormous distance against a dark background.

The intense heat radiating from the enormous molten metallic mass of which the nucleus is composed forms the coma, while its condensation when in contact with the colder regions through which the comet moves results in the accumulation of distinct masses of watery vapor, of which the surrounding envelope is composed. From the evaporation arising from the surface of the layer the process is repeated by which the various envelopes arise.

The jets of light apparently thrown out from the nucleus in the direction of the sun are molten streams, analogous to terrestrial waterspouts, drawn from the head of the comet by the force of solar attraction. As the comet approaches perihelion the solar forces become so intense as to cause the most violent excitement in the nucleus, producing the various elongating changes of form and other convulsive phenomena to which it is constantly subject. Occasionally the nucleus is torn apart or broken up by the immensity of the forces with which it is brought into immediate contact, thus forming two independent and distinct

comets, or even a multiple of them, as are recorded to have been observed.

The tail of a comet is a magnetic stream flowing from the molten nucleus. A well-known property peculiar to some metals, by which they possess a power of attraction for each other, is known as magnetism. On the earth it has been found to exist in a large proportion in an ore of iron called "loadstone." From this it may be communicated to other metallic bodies by friction, and they in like manner become possessed of the same power as that contained in the loadstone. As the nucleus of a comet consists of a molten metallic mass, magnetism exists on an enormous scale. The electrical repulsive force of the sun's corona exerted against the magnetic stream produces various changes in the train. On the approach of a comet the tail is mainly carried in the rear, and swept around and carried in advance as the comet recedes from the sun after the completion of its perihelion. The curvature sometimes observed in the tail results from the resistance of the magnetic stream to the repulsive force, the curve being formed where the resisting force becomes spent or weakest. The double or multiple tails are produced by the exciting changes occurring in the nucleus, by which the magnetic stream is forced out in other directions. The apparent separation of the tail from the head is caused by the shading of the electrical current, arising from its intersection by the nucleus. The bounding streaks extending along the tail from either side of the head, with a dark enclosure

between, may be explained by the theory suggested by Sir John Herschel, which regards the form of the tail as conical, owing to the apparently spherical dimensions of the nucleus. All the strange varieties and changes of appearance presented by the tails of comets arise from the variations of the magnetic stream in conjunction with the electrical coronal current, consequent upon the continual state of agitation and excitement of the nucleus.

In addition to comets and meteors another celestial class known as star clusters evidently originated in like manner. Myriads upon myriads of star-like forms are observed scattered in clustering groups with the utmost closeness and profusion. They were originally supposed to be stars too remote in space to be fathomed in point of distance, and from which light, travelling with its enormous velocity, required thousands of years to reach the earth. But in their clustering forms may be seen the minute fragments of shattered and shivered stars, each so small as to present the appearance of larger bodies feebly shining in the far-off regions of space. Such ruin and destruction must necessarily be the consequent result of any sudden interference with the movements of such a complicated network of intricate mechanism as that displayed in the universe. When we "consider the heavens," and reflect on the magnitude of the work of Him who counts the numbers of the stars and calleth them by name, and attempt to realize the vast effects of its partial destruction accomplished by the bidding

of man, in wondrous amazement we can but re-echo the inspired interrogatory: "What is man, that Thou art mindful of him? and the son of man, that Thou visitest him?"* "Of old hast Thou laid the foundation of the earth: and the heavens are the work of Thy hands. They shall perish, but Thou shalt endure: yea, all of them shall wax old like a garment; as a vesture shalt Thou change them, and they shall be changed: But Thou art the same, and Thy years shall have no end."†

* Psalm viii. 4.

† Psalm cii. 25-27.

CHAPTER XXII.

NEBULÆ AND STAR CLUSTERS.

AMONG the many celestial features of wonderful peculiarity are the nebulæ and star clusters. When visible to the naked eye they appear as cloud-like masses of milky light; but are found by telescopic aid to consist of a vast assemblage of star-like forms, apparently so far distant as to cause their cloud-like and nebulous appearance. Those which can be resolved into distinct and stellar forms are called star clusters, while the irresolvable agglomerations of diffused matter are known as nebulæ, of which one of the most brilliant and remarkable is that in the constellation of Orion. In appearance the nebulæ are observed to be changeable, partaking of various shapes, either circular, oval, lenticular, spiral, conical, or occasionally assuming a most fantastic form. Star clusters are generally of a spherical shape, containing thousands of apparently small, faint stars densely packed together, in some instances in such a manner as to suggest the idea of a nucleus, or power of centre. The most remarkable of the star clusters is seen in the Pleiades.

The Galaxy, or Milky Way, presents a nebular analogy. It consists of a vast stream of milky light, obliquely spanning the heavens in the form of a mag-

nificent arch. It displays a varied irregularity of outline, a portion being longitudinally divided and separated into two parts, which finally again reunite and effect a junction. Great gaps or vacant spaces, known by the euphonious appellation of "coal sacks," also exist in the Galactic belt, tending to complete the cloud-like appearance of the stream, in some of which not even a single object can be discerned. When observed with a powerful telescope its nebulous appearance is found to arise from an immense agglomeration of apparent stars, so densely clustered together in certain places, and at such a seemingly infinitely remote distance, that their combined light produces only a cloud-like form. It has been observed that the nebulae are least in the regions near the Milky Way, and that where the stars are least nebulae are found to be most abundant.

A spectroscopic analysis of the nebulae reveals the fact that the light emitted therefrom proceeds from enormous masses of glowing gas. Huggins found the spectra of the nebulae and clusters to consist of two classes, the spectrum of one resembling the sun and stars, and that of the other as though arising from irresolvable matter in an incandescent, gaseous form. Many of the star clusters, however, present a continuous spectrum, showing that the individual bodies composing them are of a stellar constitution, while in some instances a nebulous mixture is observed, arising from a compound of matter in both a solid and gaseous form.

The origin of the star clusters and nebulæ may be attributed to the disturbing causes which produced comets and meteors. The clusters are fragments of instantaneously exploded stars hovering around the central point of disturbance, while the nebulæ are vast clouds of gas, smoke and stellar debris resulting from the explosions.

This fact explains the absence of stars when the nebulæ are most abundant. The Galactic belt marks a course of utter ruin and stellar destruction, stretching from the North to the South Pole, surrounding which it appears to be uniformly spread. Its bifurcation points to a repetition of the devastating course, after an interval of time, in almost exactly the same location.

From the existence of nebulous matter in the heavens it has been supposed by many that out of this material the universe was evolved. The process by which this evolution is supposed to have taken place is described in a theory promulgated by Kant, Laplace and others. It is known as the Nebular Hypothesis, and is to the effect that the sun, planets and satellites originally existed in the form of a cosmical vapor, being rapidly contracted in volume by the radiation of heat, a process which began with the first evolution, and which is supposed to be still taking place from the earth, the planets and the sun to the present day. In point of size the nebulous mass is thought to have occupied a space as large as the orbit of Neptune, which planet, moving with a velocity of

nearly 12,000 miles an hour, requires 165 years to make one revolution. During the evolving process the atoms of which the cosmical vapor were formed began to exert a tangential force, and while gyrating through space the whole mass became distorted in form, and instead of assuming a perfectly spherical condition, assumed the shape of a flattened spheroid. The velocity of the peripheral portion afterward became accelerated and overcame the power of gravity. As a result the peripheral portion became detached and took the form of a ring, which also continued to rotate about the mass till a rupture was produced by the oscillations to which it became subject, when the material became accumulated in another globe of a similar nature, in turn revolving around the first. After the lapse of an eternity of time the original mass, under the influence of the acceleration of its motion and gradual cooling, threw off another ring, which also became evolved into a revolving globe. As this process was repeated every few million years a series of globes were formed, and these became the planets, and the original residual mass the sun. The process is still supposed to be going on, and it is thought the sun may yet throw off another ring, which in the distant future will assume the form of another planet. As each globe became detached it at once began a repetition of the process of cooling and condensation, greatly accelerating its motion. In the case of the larger planets the rotation became so rapid that a number of rings were detached before the cooling process had reached a point of liquefac-

tion. These in turn became satellites and revolved about their planets. The earth became refrigerated so rapidly that it had but time to throw off one, while others became so rigid before the requisite velocity was attained that they were unable to throw off any. Saturn threw off eight, which became satellites, and another still remains hovering around the planet, waiting for the hand of time to give it a gentle elevation into the realms of space and independence.

In the course of time the original mass of vapor became ignited, and gradually subsided in form, owing to the process of radiation. In the case of the earth a crystalline crust gradually formed over the liquid mass, and the process likewise resulted in the formation of a solid film over the surface of the molten planets. During a gradual refrigeration the stiffening crust became too large for the molten sea within, arising from the rapid contraction of the more heated parts, and a shrinkage of the crust took place, resulting in the form of wrinkles, which became the germs of the mountain chains and continents with which the surface of the globe is diversified. No water had then existed upon the earth, which was surrounded by an aqueous gas, which, when the proper time arrived, began to be reduced in temperature, and condensation was the result. Then a tremendous scene of ebullition took place, a fierce conflict between the elements—fire and water, lightning and thunder—but in process of time the fire was gradually conquered, the waters triumphed, and the first germ of land gradually

appeared. After the lapse of an extended period of time, so long as to be beyond the power of comprehension of the most intelligent being, the earth slowly crept into its present position, from which it is slowly and surely passing on to another of refrigeration, when winter will reign universally; for the sun is supposed to be rapidly cooling, and the intricate machinery of the universe, destined only for a time, is running down, and desolation will triumph and reign universal. The moon has long since passed through this refrigerating process, and as it now is so the earth will be. Such is, in brief, the substance of the Nebular Hypothesis.

In confirmation of this theory it is held that undensified nebulous matter still exists; out of material of this nature the globes were formed; that all the planets move in the same plane as if thrown off from one equator; the satellites revolve around their primaries in the same direction as the latter about the sun; that the same axial motion is common to both the sun and the planets; and that, with a few exceptions, the eccentricity of the planets is comparatively small. While the truth of the Nebular Theory has never been entirely disproved, many serious flaws and fatal objections have been pointed out. Newcomb remarks that the Hypothesis must remain doubtful "until the sun shall be found growing smaller by actual measurement, or the nebulae be actually seen to condense into stars and systems."

The main features of the Nebular Hypothesis lie in the beginning and end of the Theory. It originates in

a hot, diffused, gaseous form, and terminates in a process of refrigeration. The existing nebulæ is pointed to as the material of which the worlds were formed. This, however, has never been known to bear any similitude to rotating globes, but assumes various and fantastic shapes with enormous gaps throughout, in no way resembling the primitive stages of evolutionary world formation. The nature and origin of this nebulæ has already been explained. It is shown to be the residual gaseous matter of thousands of shattered globes. Thus, instead of being the material of which the worlds are formed, worlds formed the nebulæ. Instances of this have been observed. In November 1876, a star suddenly blazed forth with great brilliancy in the constellation of Cygnus. After a comparatively short time the star was observed to gradually fade away into a nebulous mist—an undoubted proof that the nebulæ originated from the stars, and a conclusive argument against the theory of Evolution.

The rings of the planet Saturn are shown as direct evidence of the process of the formation of satellites. The Hypothesis explains these rings as nebulous mist thrown off the planet, to be evolved during the course of untold ages into other satellites like those by which it is accompanied. Instead of further receding from the primary mass it is found by actual observation that the rings are gradually but surely approaching the planet, and are apparently doomed to collapse upon its surface. Here, again, the Theory fails; and it has already been shown that the pulverized fragments of

former satellites form the rings of Saturn, and therefore not the nebulous material of the rings that form the satellites.

Again, the end to which the Nebular Hypothesis points is a period of lifeless refrigeration. The sun and planets are to gradually become cooled off, and life cease to exist. The moon is held to have long since passed through all the successive changes required by the Theory; and as it now is so the earth and planets will also be. If such is the result with the moon, then the Theory fails to account for the origination of the crateriform mountains, the moraines, the ray or streak system, and other physical formations existing upon its surface. Until the Theory accounts for the manner in which the cooling process formed the various peculiarities on the surface of the moon, the lifeless condition of which is attributed to a direct result of the Hypothesis, the latter can only be received with the utmost suspicion.

The moon having passed through a Glacial epoch simultaneously with the earth it will be seen that its present condition is attributable to violent disturbance, and not to a gradual refrigeration, as explained by the Nebular Hypothesis.

PART II.

CHAPTER I.

PHYSICAL EVIDENCE OF A UNIVERSAL DELUGE.

SCIENTISTS and geologists are unanimous in the belief that the Glacial epoch occurred long before the Noachian Deluge, at a period of time ranging from 10,000 to 100,000 years, and yet at the same time manifest wonder and surprise at the comparatively modern appearance presented by the effects of the Drift.

Now, if the Noachian Deluge occurred after the Glacial epoch, geological evidence of the former event must be found between the Boulder formation and the surface of the earth; for no deluge such as that recorded in the Book of Genesis could have taken place without leaving some traces behind, just as the drift material was the result of the Glacial floods. But no such testimony exists. In northern countries the detritus and rocks of the Boulder formation are scattered in thousands over the face of the country. There is no trace whatever of any deposits that might have resulted from a deluge of the magnitude of that recorded in the Book of Genesis. It has therefore been held by many that no geological proof exists of

the occurrence of a universal deluge in the past. But though it is admitted there are imperfections in the geological system, the origin of which cannot be explained, the events of these periods are supposed to have taken place millions of years before the advent of man upon the earth. That such was not the case, however, is shown by the date of occurrence of the Glacial epoch. If the Noachian Deluge, therefore, was of the magnitude recorded, and took place previously to the Glacial epoch, physical proofs of the same must be found below the Boulder formation. The next gap in the geological record is that overlying the Cretaceous deposits, and between the Mesozoic and Cenozoic formations, yet not separating them, but known to roll away from the west toward the south-east until the two formations are blended into one. There is no break between the two periods, but the occurrence of a great geological event the origin of which has not yet been explained. It is held to represent a great chasm of time in the primitive history of the world, in the formation of which thousands and thousands of years are supposed to have been occupied. During this period, it is known, a great revolution of the physical features of the earth took place. An elevation of the floors of the Cretaceous seas and a subsidence of the land beneath the level of the oceans were the results, together with an almost entire obliteration of all animal life. Yet some were known to escape, such as the lingula, for example, a small shell, which has been traced to its origination in the early seas of the

Palæozoic time. The disturbance which characterized the sudden and abrupt termination of the Cretaceous period in the west included also the Eocene, or lower Tertiary, in the east. There is no break of continuity between the Secondary and Tertiary series, but merely the separation of the two by the occurrence of a great phenomenal geological event, and that event was undoubtedly a universal deluge.

Many of the sedimentary deposits of the Cretaceous period consist almost entirely of a vast accumulation of minute and invisible shells of infusoriæ, animalculæ, etc. These are of enormous extent, and occasionally hundreds of feet in thickness. The shells present a remarkable state of preservation, even the most delicate and fragile exhibiting no signs of decay or injury. No foreign material is observed in the accumulations, the whole masses being almost totally composed of inhumed animalculæ.

"The city of Richmond, in North America," as pointed out by Pouchet, "is the centre of one of these districts, where, according to the beautiful saying of Shelley, every grain of dust was once endued with life. The deposit of microscopic skeletons attains a depth of several hundred yards. If as many human mummies were laid one upon another they would form a mountain the height of which would almost equal a semi-diameter of the earth."*

A microscopical examination of a small particle of pulverized chalk shows that it is mainly composed of

* "The Universe," p. 20.

an accumulated mass of minute shells, or broken fragments of the same, in size resembling small grains of fine sand. Incalculable billions of these tiny shells compressed together form the great chalk deposits of the Cretaceous period, from which its name is derived—*creta* being the Latin word for chalk. Though inanimate now each individual shell was once endowed with life, perfect in its organization, and originally existed beneath the water. They are called foraminifera, together with others known as pteropods. Chalk has been found similar in composition with a white, slimy material dredged from the bottom of the Atlantic, called “globigerina ooze,” containing identically the same tiny shells, and which, when dry and hard, exceedingly resembles the European chalk.

From numerous deep sea soundings it has been found that the bottoms of the Atlantic, Pacific and Indian Oceans are almost entirely covered with a thick accumulation of these minute shells, existing in countless myriads, many thousands being contained in a single cubic inch. As shown by Bailey, from observations made of soundings in the North Atlantic by the United States ship *Dolphin*, the bottom, “as far as examined, from the depth of about sixty fathoms to that of more than two miles (2,000 fathoms), is literally nothing but a mass of microscopic shells,” and further, that the dredged material “did not contain a particle of gravel, sand or other recognized unorganized mineral matter, but was almost entirely made up of the calcareous shells of minute foraminifera.”

From this it is known that the great chalk deposits of Europe and other countries originally existed at the bottom of the sea. The fecundity of this class of life, or the rate at which these animalculæ individually increase, is generally admitted to be on an enormous scale, millions being reproduced in one hour. Geologists ascribe the formation of these collections to the slow and gradual deposition by marine waters during many thousands of years. Assuming the rate of deposition to be about ten inches in a century, it has been estimated that more than 120,000 years would have been required, for the formation of many of the beds, which are supposed to average 1,000 feet thick. How such masses could have been slowly accumulated during untold ages, without the least injury whatever to the shells themselves, and with an entire absence of foreign material, is not explained. By no known mode of calculation could an attempt be made to estimate in numbers the innumerable tiny shells of which the chalk deposits are formed, from the white cliffs of which Britain owed its ancient name of Albion. It consists of billions upon billions, trillions upon trillions, of invisible little creatures now dead and lifeless, but once living and spread out over the bottom of the ocean, after the manner of the "*globigerina ooze*" of the present time.

Chalk fossils have been found in both the Old and New World; in North America, at Saskatchewan and Vancouver Island, and in the United States. According to Ehrenberg the harbor of Wismar, in the Baltic,

is choked up with infusorial accumulations, and many similar formations are producing extensive changes in the geographical configuration of other places. In a single ounce of sand from the Antilles D'Orbigny estimated the number of shells of foraminifera at 3,480,000. Schleiden estimated the number of animalcules in a cubic inch of the tripoli of Bilin, in Bohemia, at 41,000,000.

According to Lyell "pure chalk of nearly uniform aspect is met with in a north-west and south-east direction from the north of Ireland to the Crimea, a distance of about 1,140 geographical miles; and in an opposite direction it extends from the south of Sweden to the south of Bordeaux, a distance of about 840 geographical miles." Above and below nearly all true chalk deposits beds of clay, marl and sand, of considerable extent, are found, containing the fossil remains of land vegetation. This means, therefore, that during this period the continent of Europe was submerged and swept by the waters of the ocean, which deposited thereon extensive masses of calcareous ooze, consisting of foraminifera, etc., such as now exist at its bottom, which resulted in the formation of the extensive deposits of what is now European chalk. The destruction of every animal and vegetable substance was undoubtedly complete.

A total destruction of life also occurred in the Orient during this geographical period. Huge masses of rock composed almost entirely of small shells known as nummulites are found in great abundance.

In the Himalaya Mountains the Nummulitic lime-stones occur at a height of 16,000 feet above the sea. The same shells are found from Burmah to Eastern Bengal, and in Persia, Syria, in Asia Minor, along the Caspian Sea, and in Egypt. Not only this vast area but the whole continent of Asia is known to have been completely submerged at this time.

The Carpathian Mountains, as well as the Apennines, in Europe, were elevated during the same period.

"The Nummulitic formation, with its characteristic fossils," says Lyell, "plays a far more conspicuous part than any other Tertiary group in the solid frame-work of the earth's crust, whether in Europe, Asia or Africa. It often attains a thickness of many thousand feet, and extends from the Alps to the Carpathians, and is in full force in the north of Africa, as, for example, in Algeria and Morocco. It has been traced from Egypt—where it was largely quarried of old for the building of the pyramids—into Asia Minor, and across Persia, by Bagdad, to the mouth of the Indus. It occurs not only in Cutch but in the mountain ranges which separate Scinde from Persia, and which form the passes leading to Cabul; and it has been followed still further eastward into India, as far as Eastern Bengal and the frontiers of China. . . . When we have arrived at the conclusion," he adds, "that the Nummulitic formation occupies a middle place in the Eocene series, *we are struck with the comparatively modern date* to which some of the greatest revolutions in the physical geography of Europe, Asia and Northern

Africa must be referred. All the mountain chains, such as the Alps, Pyrenees, Carpathians and Himalayas—into the composition of whose central and loftiest parts the Nummulitic strata enter bodily—could have had no existence till after the Eocene period.”*

The city of Paris, in France, is built almost entirely of stone composed solely of minute shells known as the miliolæ. In size they have been compared to that of a grain of millet, often less, and are found in such abundance that whole mountains, consisting entirely of these small shells closely cemented together, have been quarried, and the stone used for building purposes.

It is known that the region of the Alps, in Switzerland, was completely submerged during the Secondary period, and at the close of the Eocene period the enormous sedimentary beds deposited on the bottom were elevated and twisted into the various complicated foldings which they now present.

On the north and south of the Alps there are stratified beds of unfossiliferous sandstone, many thousand feet thick, containing granitic and limestone boulders altogether foreign to their present location. Many of them are of vast proportions, and present a similarity to the rounded and angular blocks of the drift. One of these erratics, near the Lake of Thun, is 105 feet long, 90 feet wide and 45 feet thick.

The testimony of several eminent geologists as to the phenomenal events of the Cretaceous period may be here recorded. Speaking on the geology of the Ter-

* “Elements of Geology,” p. 305.

tiary formation of Dakota and Nebraska, in America, Prof. F. V. Hayden says: "From the observations which have already been made we believe that at the close of the Cretaceous period *the ocean rolled uninterruptedly across the area now occupied by the Rocky Mountain ranges*. Whether some portions of the mountain peaks did not project above the ocean waters during that period it is impossible now to determine, but the evidence seems to be quite clear that the greater part of the country, at least, *was beneath the ocean level* during that period. Near the close of the Cretaceous era the surface had reached an elevation so great as to form long lines of separation between the waters of the Atlantic on the east and those of the Pacific on the west; and then this great watershed began to rise above the surrounding country. Then also began the existence of the first of that series of fresh-water lakes which we now know was a prominent feature in the physical geography of this country during the Tertiary period. To obtain a clear idea of the plan of growth of the western portion of our continent, as it quietly and slowly emerged from the ocean, we have but to study the numerous barometrical sections which have been constructed by the U. S. army officers and others for the past twenty or thirty years. Taking almost any point along the Missouri river below Council Bluffs we find that as we proceed westward there is a gradual elevation or ascent of about one foot to the mile for the first hundred miles, then three feet for the second, five feet for

the third, eight or nine feet for the fourth, etc., until at the foot of the mountains the ascent becomes eighty or ninety feet to the mile. We then pass over a series of mountain ranges of different elevations until we reach the western or Pacific slope, when we gradually descend into the ocean. We thus conclude that during the Cretaceous period there was a gradual slow elevation of the whole country west of the Mississippi; that about the close of that period the crust of the earth had been strained to its utmost tension, and long lines of fracture commenced, which formed the nucleus of our present mountain ranges; for the evidence seems to indicate that there was a long period of quiet elevation, the central force acting along the lines of upheaval. The barometrical profiles seem to indicate that the west forms a vast plateau, upon which are located a great number of ridges or mountain ranges, tending in the aggregate nearly north-west and south-east. At the close of the Cretaceous period, when the crust had been elevated to its utmost tension, it broke, sometimes in long lines of fracture, which gave birth to these lofty continuous ranges with a granitoid nucleus along the eastern portion of the Rocky Mountains, as the Wind River, Big Horn, Laramie Mountains, or to the Black Hills, or the basaltic ridges, which are less regular in their structure, formed by outbursts of melted matter arranged in a series of sharp peaks, or sierras, as they are called in the Spanish countries, of which the Wasatch, Green River Mountains, and numerous ranges on the Pacific coast, are examples.”*

* “The Extinct Mammalian Fauna of Dakota and Nebraska,” p. 9,

"The sea covered a large part of the region of the Andes," observes Dana, "as well as of the Rocky Mountains, and both chains were to a great extent not yet flexed into mountain-shape; the Alps, Pyrenees and Himalayas *were also under water*, or only in their incipient stages of elevation. . . . The complete extermination of species at the close of the Cretaceous period has not been fully explained."*

"In England," says Archibald Geikie, "the interval between the Cretaceous and the next geological period represented there by sedimentary formations is marked by the abrupt line which separates the top of the chalk from all later accumulations, and by the evidence that the chalk seems to have been in some places extensively denuded before even the oldest of what are called the Tertiary beds were deposited upon its surface. There is evidently here a considerable gap in the geological record. We have no data for ascertaining what was the general march of events in the south of England, between the eras chronicled respectively by the upper chalk and the overlying Thanet beds. So marked is this hiatus that the belief was long prevalent that between the records of the Mesozoic and Cenozoic times there comes *one of the great breaks in the geological history of the globe*. . . . Though in Western Europe there is a tolerably abrupt separation between the Cretaceous and Tertiary deposits, there was, nevertheless, no real break between the two periods. The one merged insensibly into the other;

* "Manual of Geology," pp. 491, 504,

but the strata which would have served as the chronicles of the intervening ages have either never been deposited, or have since been in a great measure destroyed.”*

According to Figuier, at the close of the Cretaceous period “Europe was still far from displaying the configuration which it now presents. A map of the period would represent the great basin of Paris (with the exception of a zone of chalk), the whole of Switzerland, the greater part of Spain and Italy, the whole of Belgium, Holland, Prussia, Hungary, Wallachia and Northern Russia, *as one vast sheet of water*. A band of Jurassic rocks connected France and England at Cherbourg, which disappeared at a later period, and caused the separation of the British Islands from what is now France.”†

In the Orient similar conditions prevailed during this geological period. In an account of the journeys of the Persian Boundary Commission, in 1870-72, W. T. Blanford says: “It is evident that during Cretaceous times the greater portion, and probably the whole, of Southern and South-western Persia *was beneath the sea*. . . . Towards the close of the Cretaceous epoch a great change took place, accompanied by volcanic outbursts in the Caucasus, over a great area in Western India, and probably in several parts of Persia, and the result was the elevation of the Zágros range, and perhaps of the country now forming the Persian plateau. The south-west slopes of the Zágros, and the country

* “Text-book of Geology,” p. 835. † “The World before the Deluge.” p. 271.

on the coast of the Persian Gulf and the Arabian Sea, were, however, still *beneath the ocean* in early Tertiary times, and the Nummulitic sea extended far to the eastward along the southern slopes of the Himalayas, and very possibly occupied the plains of Northern India and the Punjab. It certainly covered nearly the whole, if not the whole, of Baluchistan and Sindé."*

From the foregoing accounts it will be seen that at the close of the Cretaceous period the various countries all over the globe where geological observations have been made were entirely submerged beneath the waters of the ocean, even the then existing mountaintops being covered. Many ranges which had no existence previous to this period were thrown up, and many others have originated since that time.

Thus was there a deluge, not only universal in character and destruction of animal life, but one in which there is evidence that every living substance perished. The vegetation of the succeeding periods is of an entirely different nature from that which preceded that event. A class immediately sprang up correlative with its environment. Aquatic plants predominated, and the abundance of luxuriant ferns of the Eocene period prove a moist and foggy atmosphere, which would naturally result from the evaporation of surplus water from the rapidly-drying land.

In succeeding flora the first gymnosperms, or naked-seeded plants, appear, while previous to the flood only angiosperms, or plants having their seeds enclosed in seed vessels, had an existence.

From this time on the earth enjoyed a mild, warm climate during the Miocene period, gradually becoming cooler in the Pliocene, until it had attained a temperature at its close nearly equal to that of the present day. The termination of the Pliocene period witnessed the Glacial epoch and the sudden and temporary change of climate by which it was accompanied.

CHAPTER II.

THE DELUGE OF NOAH.

MANY of the earlier geologists struggled in vain to identify the Drift deposits as the result of the Noachian Deluge. A further investigation proved that such was not the case, for the events of the Glacial period were found to be of a local character; and though man existed upon the earth at the time of their occurrence, entire races escaped its effects in various directions. No geological evidence existing of the occurrence of a universal deluge since the close of the Drift period, it is held that the Noachian Deluge was not of a universal nature, but a local catastrophe, confined to the neighborhood of the country where the narrated events took place. The explanation given in Figuier's "The World before the Deluge" expresses a very general and almost unanimous view held by many scientists respecting the flood described in the Mosaic account, in attributing its origin solely to a natural cause in the ordinary course of geological events.

"The Asiatic Deluge," he says, "of which sacred history has transmitted to us the few particulars we know, was the result of the upheaval of a part of the large chain of mountains which are a prolongation of

the Caucasus. The earth opening by one of the fissures made in its crust in course of cooling, an eruption of volcanic matter escaped through the enormous crater so produced. Masses of watery vapor or steam accompanied the lava discharged from the interior of the globe, which, being first dissipated in clouds and afterwards condensing, descended in torrents of rain, and the plains were drowned with the volcanic mud. The inundation of the plains over an extensive radius was the instantaneous effect of this upheaval, and the formation of the volcanic cone of Mount Ararat, with the vast plateau on which it rests, altogether 17,323 feet above the sea, the permanent result. 'In the six hundredth year of Noah's life, in the second month, the seventeenth day of the month, the same day were all the fountains of the great deep broken up, and the windows of heaven were opened. And the rain was upon the earth forty days and forty nights. . . . And the flood was forty days upon the earth; and the waters increased, and bare up the ark, and it was lift up above the earth. . . . And the waters prevailed upon the earth an hundred and fifty days.' All the particulars of the Biblical narrative here recited are only to be explained by the volcanic and muddy eruption which preceded the formation of Mount Ararat. The waters which produced the inundation of these countries proceeded from a volcanic eruption, accompanied by enormous masses of vapor, which in due course became condensed and descended on the earth, inundating the extensive plains which now stretch

away from the foot of Mount Ararat. The expression 'the earth,' or 'all the earth,' as it is translated in the Vulgate, which might be implied to mean the entire globe, is explained by Marcel de Serres (in a learned book entitled 'Lea Cosmogonie de Moïse') and other philologists as being an inaccurate translation. He has proved that the Hebrew word *haarets*, incorrectly translated 'all the earth,' is often used in the sense of region or country, and that in this instance Moses used it to express only the part of the globe which was then peopled, and not its entire surface. In the same manner the 'mountains' (rendered 'all the mountains' in the Vulgate) only implies all the mountains known to him. Similarly, M. Glaire, in the 'Christomathie Hébraïque,' which he has placed at the end of his Grammar, quotes the passage in this sense: 'The waters were so prodigiously increased that the highest mountains of the vast horizon were covered by them,' thus restricting the mountains covered by the inundation to those bounded by the horizon. . . . It" (the Deluge) "*was local, like all phenomena of the kind*, and was the consequence of the upheaval of the mountains of Western Asia."

Many ingenious attempts have been made to contort the Mosaic account with theories of this kind, *all* the particulars of which, it is held, "are only to be explained by the violence and muddy eruption which preceded the formation of Mount Ararat."

Now, it can be easily conceived how immense masses of steam rising upward would be condensed and de-

scend in torrents of rain ; but how can it be sensibly understood that the inundation of the plains with volcanic mud was the producing cause of a flood at all identical with that recorded in the Bible ?

This theory, it is held, is the only one that will explain all the particulars of the Biblical narrative. Granting temporarily its local origin and effect, and the benefit of an alleged mistranslation, in what manner are any of the particulars accounted for as recorded in Genesis ? How does it explain the *going* and *returning* of the waters, and the great wind which passed over the earth when the waters were assuaged ? How were the fountains of the great deep broken up and the windows of heaven opened ? and how did the waters return from off the earth continually until all were abated ? Instead of explaining *all* the particulars of that event, Figuier's theory explains none. If the Deluge were local and the result of the upheaval of a long chain of mountains in Western Asia, there would have been no necessity for Noah spending one hundred and twenty years making preparations for such a disturbance, the effect of which could have been easily escaped by migrating to a far country. And why should the animals be preserved in one particular locality for the purpose of continuing their existence, and roam free and undisturbed in other parts of the globe. To maintain a belief in the occurrence of a partial deluge in the East is a frank admission that man was there localized, and had not as yet spread over the western hemisphere. And if the

Glacial events took place thousands of years previous to the Noachian Deluge, as is generally believed, it remains to be explained how man existed in Europe and America during the Glacial period, and yet was confined to the eastern hemisphere 4,000 years ago, and within such a small radius that the human race could have been exterminated by a local flood. If the existence of a deluge is admitted, and its visitation the result of a denunciation by the Creator, it is incredible that such should have been the effect of an ordinary second cause to the exclusion of Divine interposition. "And God said unto Noah, The end of all flesh is come before me; for the earth is filled with violence through them; and, behold, I will destroy them with the earth. . . . And, behold, *I, even I, do bring a flood of waters upon the earth*, to destroy all flesh, wherein is the breath of life, from under heaven; and every thing that is in the earth shall die."* If such an event actually took place and for the reason ascribed, then all the particulars narrated by Moses must be accepted in a literal sense, without the slightest contortion of the text whatever.

There need be no hesitation whatever in pointing to the upper Cretaceous deposits as the physical result of the Noachian Deluge, and that they were accumulated there within a period of one year instead of having been the accumulation of sedimentary matter for hundreds of thousands of years, as has been supposed.

There is a peculiarity connected with this deposit (just as there are peculiarities in the Drift formation)

* Gen. vi. 13, 17.

that point to the means employed to bring about the events narrated in the seventh chapter of Genesis. The line of demarcation in the western hemisphere is very abrupt, while it gradually slopes away off to the south-east until the underlying and overlying strata are merged into one, showing plainly and clearly that the waters which deposited this diluvium came from the east and flowed towards the west.

The earth in its axial revolution, as is well known, travels from west to east, and the waters of the oceans are carried in the same direction. Therefore a reversal of this motion would produce this peculiarity, and at the same time cover all the particulars of the Biblical narrative exactly, without in any manner attempting to contort the text or misconstrue its meaning. It is clear that by Divine interposition the axial motion of the sun was reversed, and the earth and the planetary system revolved from east to west in a manner directly opposite to that which now obtains. Instantly the reversal took place the waters of the Pacific Ocean rose in a heap, and were carried with the motion of the earth in one immense torrent over the eastern hemisphere, and the waters of the Atlantic rose and poured in a body over the continent of America into the vacancy created by the flow of the Pacific. As the earth revolved in this manner the waters rose higher and higher until the mountain tops were covered and the whole earth was submerged. And as it continued "the waters increased, and bare up the ark, and it was lift up above

the earth. And the waters prevailed, and were increased greatly upon the earth; and the ark went upon the face of the waters. And the waters prevailed exceedingly upon the earth; and all the high hills, *that were under the whole heaven*, were covered. Fifteen cubits upward did the waters prevail; and the mountains were covered. And all flesh died that moved upon the earth, both of fowl, and of cattle, and of beast, and of every creeping thing that creepeth upon the earth, and every man: all in whose nostrils was the breath of life, of all that was in the dry land, died. And every living substance was destroyed which was upon the face of the ground, both man, and cattle, and the creeping things, and the fowl of the heaven; and they were destroyed from the earth: and Noah only remained alive, and they that were with him in the ark. And the waters prevailed upon the earth an hundred and fifty days."*

The intense heat of the earth, caused by the stirring up of the molten mass in its centre, and assisted by the increased heat of the sun, which must have been emitted owing to the change of motion of that luminary, completely enveloped the earth in steam and vapor, and this rising into the colder regions became condensed and descended, not in ordinary rain, but in immense water-spouts and torrents on the earth.

"The fountains of the great deep were broken up, and *the windows of heaven were opened*. And the rain was upon the earth forty days and forty nights."†

* Gen. vii. 17-24. † *Ib.*, vii. 11, 12.

In the first verse of the eighth chapter of Genesis it is recorded that "God made a wind to pass over the earth, and the water assuaged." Here is described the effect of the reversal of the motions of the sun and the earth to their former relations, a universal cyclone of wind being carried around the globe as the earth stopped in its course and revolved in an opposite direction. Then "the waters returned from off the earth continually: and after the end of the hundred and fifty days the waters were abated." In this manner resulted their going and returning, as so briefly and yet fully detailed in the Mosaic narrative. By this means the ark would drift away towards the west with the first flow of the waters, and return again to the east with their return. It is also recorded in the last verse of the eighth chapter that God said in his heart: "While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease." This would imply that these phenomena were all interrupted by reason of the Deluge. Thus it can be seen how day and night would cease by the reversal of the earth on its axis. When the sun appeared overhead on the first day of the Deluge the day would cease and the sun appear to go back again and set in the east where it had previously risen. In the days of Joshua and Hezekiah the day and night did not *cease* but were *prolonged*, thus verifying the promise recorded in Genesis.

It may safely be held that no event is more faithfully detailed or more fully recorded than this brief

and distinct narrative of Scripture, and probably none so universally believed in by almost every nation on the face of the globe.

According to those who maintain a continued uniformity in all terrestrial changes the Deluge described by Moses is held to have been slow and gradual in its action and result. No impetuosity of force is supposed to have occurred, but merely the descent of rain upon the earth, and a gentle rising and subsidence of the waters. This assertion is flatly contradicted by the statement recorded in Genesis vii. 11. "In the six hundredth year of Noah's life, in the second month, the seventeenth day of the month, *the same day* were all the fountains of the great deep broken up, and the windows of heaven were opened." That the event could have been slow and gradual, and all the fountains of the great deep broken up in one day, is absurd. The entire obliteration of all animal and vegetable life by a gentle and ordinary rainfall of forty days and forty nights is an idea rather difficult to reconcile, even by those whose faith in miracles is not shaken.

A principal objection urged against the universality of the Noachian Deluge has been that there is no geological evidence of such an event ever having taken place. But there are admitted imperfections in the geological system that require explanation. There are enormous gaps in the record that have hitherto remained unsolved, and one of the most prominent of these, in point of importance, is the break which divides

the Mesozoic from the Cenozoic formations. That the events of this period were of a world-convulsing nature, and were produced entirely by a breaking up and complete submergence of the land by water, are facts universally admitted by geologists.

The great chalk cliffs, consisting almost entirely of tons upon tons of animalculæ, were formed during this period. But how, it may be asked, were they accumulated to such an extent above the present waters of the ocean and deprived of life? "The mind grows bewildered," says Pouchet, "in trying to find out in what mysterious way these many invisible animalcules could be accumulated to form such extraordinary heaps of corpses."*

They were rolled up from the sea bottom during the deluge, when the axial motion of the earth was reversed, and dried and hardened by the intense heat generated from the interior of the earth. In no other way could they have been deprived of existence and accumulated in the present manner. Thus it will be seen that even the invisible animalculæ perished, as recorded in the words of Scripture: "All in whose nostrils was the breath of life, of all that was in the dry land, died. And every living substance was destroyed which was upon the face of the ground, both man, and cattle, and creeping things, and the fowl of the heaven."†

It is further objected that it would be an impossibility for Noah to collect couples and septules of all

* "The Universe," p. 19.

† Gen. vii. 22, 23.

the animals then existing upon the globe, within a short period, or even during his lifetime. There is not the slightest intimation in the Mosaic narrative that he did so. On the contrary, it is expressly stated that the animals were brought to Noah for their preservation, "Of fowls after their kind, and of cattle after their kind, of every creeping thing of the earth after his kind, two of every sort *shall come unto thee*, to keep them alive."* And it is further narrated that Noah and his family went into the ark first, and the animals followed afterwards. "And Noah went in, and his sons, and his wife, and his sons' wives with him, into the ark, because of the waters of the flood. Of clean beasts, and of beasts that are not clean, and of fowls, and of every thing that creepeth upon the earth, *there went in* two and two unto Noah into the ark, the male and the female, as God had commanded Noah."† From this it is plainly evident that a Guiding Hand superintended the preparation and performed a part that might have otherwise seemed to have been an utter impossibility for Noah.

Another objection to the universality of the Deluge is pointed to in the geographical distribution of animals throughout the globe. In each particular climatal district there are found groups of animals of a nature peculiarly adapted to the regions in which they are located, and from which it would be fatal to venture beyond certain assigned limits. Thus the fauna of the tropics could not migrate to the Arctic regions, nor

* Gen. vi. 20.

† *Ib.*, vii. 7-9.

those of the Arctic regions to the tropics, under the present climatal conditions, for, with a few exceptions, they are not endowed with the power of accommodating themselves to every climate. Man and the domestic animals which accompany him are the only cosmopolites; to all others there is a prescribed boundary beyond which they may not venture.

From this it is affirmed that the animals saved in the ark could never have been dispersed to their respective locations throughout the earth if they had been released from the same centre of distribution. It is held that they could not survive the climatal immigration before each species could find the locality best adapted to their nature.

The geological location of the Deluge in the Mesozoic period forms a satisfactory explanation to this seeming difficulty. A tropical climate prevailed at that time over the greater part of the globe, as shown by the animal and vegetable remains of the Secondary rocks. This is explainable by the fact that the earth was then in its infancy and its surface much nearer the internal source of heat than at present; and further, that none of the great catastrophes had previously occurred by which the crust afterwards became thickened to an enormous extent. Immediately after the Deluge, when the whole world had been swept by the waters, a genial climate prevailed, as attested by the flora of the Eocene times.

"The lower Tertiary period," says Lecoq, "constantly reminds us of the tropical landscape of the present

epoch in localities where water and heat together impress on vegetation a power and majesty unknown in our climates. The algæ, which have already been observed in the marine waters at the close of the Cretaceous period, represented themselves under still more varied forms in the earlier Tertiary deposits, when they have been formed in the sea. Hepaticas and mosses grew in the more humid places; many pretty ferns, as pectopteris, tæniopteris and the equisetum stellare (pomil), vegetated in cool and humid places. Trees predominate here as in the preceding period, but the great numbers of *aquatic plants* of the period are quite in accordance with the geological facts, which show that the continents and islands were intersected by extensive *lakes and inland seas, while vast marine bays and arms of the sea penetrated deeply into the land.*"

When such climatal conditions prevailed on the earth immediately after the flood the geographical distribution of animals was a matter of easy accomplishment.

The gigantic quadrupeds of the Tertiary epoch appear suddenly after this event, none of their remains having been found previous to this period. It by no means follows, however, that such did not formerly exist. These huge animals would have been carried by the flood to the bottoms of the present oceans, and there be buried and forever lost to sight.

The capacity of the ark for the purpose for which it was intended is held to have been altogether inade-

quate to provide the necessary accommodation for the animals sheltered within it.

According to calculations made from its dimensions, counting a cubit as 18 inches, the tonnage of the ark has been estimated at not less than 40,000 tons, and equal in carrying capacity to a fleet of ten war vessels of 4,000 tons each. Allowing 21 inches to a cubit the length of the ark reaches 525 feet, its breadth 87 feet 6 inches, and height 52 feet 6 inches. Its capacity would be equal to 2,500,000 cubic feet. On this basis Prof. Hitchcock has demonstrated that the ark was more than equal to the occasion. "Allowing that there are a thousand species of mammalia, 600 kinds of birds, 2,000 of reptiles, and 120,000 insects," he says, "allow a million cubic feet for mammalia, 800,000 cubic feet for birds, 100,000 cubic feet for reptiles, and 100,000 cubic feet for insects, and there would be half a million of cubic feet still left for Noah and his family."

The account in the narrative of the dove sent forth by Noah, which brought back an olive leaf, is taken as indicating that the vegetation was not even destroyed, as the waters were almost abated and the land about to appear. But by no means is the inference warrantable that the tree did not escape destruction. The leaves might still retain evidence of vitality; but whether the trunk was uprooted or remained upright on the spot where it grew it would undoubtedly perish on exposure to the heat of the sun, after the waters in which it had been totally submerged for nine months

had abated. Another period of three months was further required for the subsidence of the waters after the return of the dove, and there was then ample time in which to effect its destruction. But the objection raised against any disastrous effects arising from the flood by a reference to the circumstances connected with the olive leaf and the survival of the tree is a mere technicality, based entirely on an unaffirmed supposition, for which not the slightest intimation is to be found recorded in the narrative.

It has been held, further, that even if the Deluge were universal, every living thing could not have perished, and that fish and marine animals would not require shelter in the ark, water being their native element. But it is by no means impossible to "drown a fish." Marine animals could not exist in fresh water, nor fish peculiar to rivers and lakes exist in saline waters. The conditions favorable to their existence were destroyed by the co-mingling of waters during the flood. A whale or shark could not possibly survive a journey over two or three thousand miles of inundated land; and even if so it would find no means of sustenance, owing to the entire destruction of life in its former circumscribed limit.

It is also objected that unless a continental subsidence took place the amount of water requisite to cover the entire globe above the tops of the highest mountains would increase the mass of the earth to such an extent as to derange its celestial harmony. To cover the mountain tops would require a volume

of water about five miles above the present ocean level, and about eight times greater than at present existing on the globe. The evaporation of such a body of water, it is held, could not possibly take place within the period of time to which the limits of the Deluge is assigned; and if so the atmosphere surrounding the earth would be entirely inadequate for such a support.

An explanation of the manner in which the globe was entirely enveloped by water sufficient to cover the mountain tops without deranging the solar system explains this seeming difficulty. The reversal of the earth's axial motion would produce the effect, and the overflow of the oceans would be a direct consequence of an opposite change in the rotary motion of the earth.

The occurrence of the Deluge in this manner will be found to explain many of the supposititious technicalities which have been urged against the destruction of the earth by a flood, "whereby the world that then was, being overflowed with water, perished,"* as well as other particulars of that event recorded in the Holy Scriptures.

* 2 Peter iii. 6.

CHAPTER III.

THE ANTEDILUVIAN WORLD.

BEFORE the Cretaceous period, or that which witnessed the Noachian Deluge, the Triassic and Jurassic formations were laid down. During the former period a rich and luxuriant vegetation flourished, and a great swarm of huge, uncouth reptiles suddenly appeared upon the earth. Among them were the great crocodilian rhizidonts, the protosaurus, notosaurus and labyrinthodon. Gigantic amphibia occupying an intermediate position between the fishes and mammals also suddenly appeared. The ichthyosaurus, or fish-lizard, was about thirty feet in length, with a head like a crocodile, four paddle fins, and a body resembling a fish. The plesiosaurus was of a similar nature, but possessed a long, flexible neck like that of an aquatic bird. A gigantic flying reptile, with long fingers like those of a bat for the support of wings, and a head resembling an alligator, lived during this period, and is known as the pterodactylus. Other reptiles, batrachians and similar animals made their appearance, as indicated by the abundance of their fossil remains.

And here man first appeared in an extra-tropical world of the richest vegetation, and coeval with the

gigantic reptiles and saurians of this primitive time. By no means can his location be placed at the close of the Tertiary period, after the Glacial epoch. The absence of human remains in the Western world does not imply the non-existence of human life on the globe. It merely indicates the absence of man from that particular region. Man's origination began in the Orient. The whole world was peopled from one pair. For fifteen hundred years after creation the place of human abode was confined within a circumscribed limit. In the East he lived and died, and it was not till after the Noachian Deluge that man began to be scattered over the face of the earth. Mankind also attained a considerable longevity. The first man lived nine hundred and thirty years, and yet he was not the oldest. The deaths were comparatively few until a certain increase in population had been attained. It would be impossible to find remains of man in the Cretaceous formation of the Western world, where he never existed. Nor would his remains be found in the East at that geological period, for they would, in all probability, have been interred by his companions, and have long since decayed out of existence. In the case of animals it was different. Dying in caves and places of retreat, without interment, their bones became liable to petrification by exposure to favorable elements, while those of the former would putrify and crumble out of existence. A period of probably two thousand years elapsed after creation before man found his way to the West, and this would be geologically close to the

middle of the Tertiary period, where his remains are now occasionally found. From the Palæozoic period onward it is well-known that the Oriental continent has maintained a lead in the scale of zoological progression. Its fauna and flora have been always more numerous in species and varied in genera than that of any other part of the globe, and no place seems to have been better accommodated for the existence and development of the highest forms of animal life than the East. As man stands pre-eminently at the head of all animal creation, from here he must have undoubtedly originated, along with the higher mammals, and afterwards spread over the globe.

The Jurassic period followed. The previously existing vegetation became rank and luxurious, and the great reptiles swarmed in hordes. In America the Triassic and Jurassic form apparently one series, not being so distinctly separated as in Europe, and the period is thus known as the Jura-Triassic. In the Cretaceous period, which followed the Jurassic, the remains of the animals found are numerous, and in many instances nearly identical with those of the present time. Up to this period there had been no perceptible effect of the seasons witnessed in the various geological formations. Here for the first time the change is seen in the autumnal nature of the vegetation. If the earth had previously existed through an eternity of ages, as has been maintained, receiving the rays of the sun in the same manner as it now does, month after month and year after year, it

is an entirely inexplicable fact how the climate had remained uniformly unchanged previous to this period without the slightest variation whatever. The Cretaceous period was brought to a close by the occurrence of a great geological event that apparently obliterated all animal and vegetable life. Yet in a mysterious manner some of the animals bridged the chasm separating the Cretaceous from the Tertiary formations. That event was the Noachian Deluge, and the ark the means by which they escaped, only to be partially, and in many instances totally, exterminated by the catastrophes of the Glacial period.

PART III.

CHAPTER I.

THE CARBONIFEROUS PERIOD.

THE Coal formation includes the development of the most remarkable class of vegetation that ever existed upon earth. Great bogs, swamps and marshes, interspersed here and there with large patches of dry land just risen above the level of the surrounding water, formed the main features of the present physical world in that primitive period of the earth's infancy. There were no rivers or streams, no pleasant plains or smiling fields—nothing but a vast extent of oozing, dripping mud, just emerged from the surrounding ocean, while in other parts rocky and elevated hills of granite had previously risen from the main and gazed peacefully on the forming world from their lonely regions of primeval solitude. Out of the rising land sprang up a rank and rapidly-developed vegetation totally different from any known to exist at the present day. Gigantic ferns, reeds, mosses and plants of a similar nature grew, flourished and passed through their different stages of existence with amazing rapidity. A damp, warm soil and a saturated atmosphere of carbonic acid, through which no ray of sun-

light penetrated, also aided their development. In those vast and dismal swamps all was dark and silent. No aerial animal ever trod those noisome jungles, and no feathered bird ever flew among the branches of their arborescent ferns or towering lepidodendra. No sound was heard save the hoarse croak of an odd batrachian or the gurgling splash of a scaly ganoid in the muddy and brackish waters of the quiet lagoons. All was a lonely wilderness of solitary grandeur.

The flora was mainly of a cryptogamous nature, such as ferns, mosses and fungi. In the more dry and upland regions the coniferæ, an order of plants bearing cones, grew in abundance. The coniferæ of the present time, such as the pines and cypress, produce dry, scaly seed vessels. The fruit is biennial and produced in the spring, but does not ripen or drop until the spring of the following year. All the species are resinous, which renders most of them evergreens.

The sigillaria were giants of the Coal period. Tall cylindrical trunks, fluted with perpendicular rounded ribs, and a spreading base, gave them a monumental appearance. Rows of pits or spots left on the ribs mark the fallen leaflets. A few thick branches covered with grass-like leaves terminated the cylindrical trunks, on which long strings of nut-like seeds encircled the stems. A large, pithy centre, surrounded by cellular, corky tissue, and the whole enveloped in a hard bark or rind, formed the material of which the trunks were composed. They grew in clumps in the swampy flats, and their thick, round roots were for-

merly supposed to have been independent plants, known as stigmaria. These are marked by round indentations or pits, from which long, cylindrical rootlets spread, and are found in great numbers in the underclay of the coal seams. Here also grew the calamites, with tall, slender, cylindrical stems, striated, jointed at intervals, and showing the marks where the leaves had been detached. They are supposed to have been allied to the equisetæ, or horse-tail plants of the present time. The latter are imperfectly-formed plants whose real affinity is uncertain. They are leafless, and branched with striated hollow stems, in the cuticle of which is secreted silica to the amount of nearly half their weight when dried. They are known as horse-tails, and are found in wet and boggy soils. The calamites grew on muddy flats, in thick, dense brakes, and from their bases clumps of plants budded out from the stem, which enabled them to secure a firm foothold by their long and numerous cord-like roots. The first bore spore cases, and resembled a spike or long cone.

The ferns of the Coal period were abundantly numerous and of great size. Some of them presented a most peculiar appearance with large, thick stems bearing their fronds on two rows, one on each side of the trunk. Large depressed areolas remain on the stem, showing where the fronds originally grew.

One of the most common genus of plants was the lepidodendron, so named from the scaly appearance of the stems, which were produced by the separation of

the leaf stalk. It presented the appearance of a gigantic club moss, with tall and graceful branches, bifurcating in a regular manner, and covered with slender and pointed leaves. The extremities of the branches terminated in fructification cones, containing spores instead of seeds. It resembled the sigillaria in having an interior of a pithy nature surrounded by a hard and cork-like rind.

Various fruits, flowers and nuts have been found in great abundance in the Coal formation, and are supposed to be the production of the coniferæ or sigillaria. Nut-like fruits, enclosed in a husk or rind, spikes of fruits protected by bracts, others large and oval with their sides striated, and some fringed or margined, are characteristic of the first land vegetation which grew on the earth.

Such was the physical aspect of the period known as the Carboniferous age, and probably no formation in the crust of the earth has been more misleading regarding the period of time required for its accumulation than that which now forms its existing coal beds.

It is generally estimated that thousands of years must have elapsed in order to have accumulated enough material to form the present coal seams. Supposing that a similarity existed in the manner and extent of growth and foliage with plants of a like nature at the present day, it is held that a long period of time was necessary to their development, and after ages had past a slow and gradual submergence of the

land took place; that the vegetation gradually decayed and became buried beneath the accumulating detritus of ages, and after another lapse of time the land became habitable, and other fauna and flora appeared.

In all probability this would have been the case were the conditions then existing the same as now. But they were not. The one grand mistake made in geological study has been in assuming that the operations in force in times past and the present existing conditions have always been the same, and endeavoring to ignore the working in nature of a Supreme Being. A close investigation and a thorough scrutiny of the peculiarities connected with the flora of the Coal deposits will show that the vegetation which existed upon the earth during that period was of an ephemeral nature, and had a very short existence of not more than one or two days. An examination of the fossilized plants plainly indicates that they were all of a rapid growth and of a cryptogamous nature, such as the calamites, equisetæ, or gigantic horse-tails, fungi and algæ, or sea-weed, and other plants of a reed-like and pithy nature. Vegetation of such forms as those described could only have existed in dark, warm, moist places; and as the plants of the coal beds disappeared, and none of the same nature were afterwards known to exist, it is clearly evident that the physical conditions under which they flourished have also disappeared and have never after been reproduced. These coal beds are found all over the world

—in the Arctic regions as well as in the tropics; and the vegetative remains of the one are exactly identical with those of the other. This would imply that an equable temperature existed all over the globe; for if not there would be a marked difference between the plants growing in the different zones, owing to the influence of climate on the growth of vegetation. Unless the climate was moist and warm these plants could not exist, and this could not be the case unless the globe were enveloped in a heavy fog, and at the same time free from winds or storms. Now, if the heat of the sun was of a proper temperature to nourish these plants in the Arctic regions, it must have been of a still greater temperature in the tropical regions, and thus kill the vegetation there, for these plants could only have existed in dark and shady places. And if the heat was of the proper temperature in the tropical regions, those in the temperate and Arctic regions could not survive the colder climate of the North.

“In the present world,” Dawson observes, “the flora most akin to that of the Coal period is that of moist and warm islands in the southern hemisphere. It is not properly a tropical flora, nor is it the flora of a cold region, but rather indicative of a moist and equable climate. . . . Further, we must not assume that the climatal conditions of the northern hemisphere were in the Coal period at all similar to those which now prevail. . . . Again, there is much in the structure of the leaves of the coal plants, as well as in the

vast amount of carbon which they accumulated in the form of coal and the characteristics of the animal life of the period, to indicate, on independent grounds, that the carboniferous atmosphere differed from that of the present world in this way, or in the presence of more carbonic acid—a substance now existing in the very minute proportion of one ten-thousandth of the whole, a quantity adapted to the present requirements of vegetable and animal life, but probably not to those of the Coal period.”*

“A moist and warm climate,” says Dana, “produces exuberant growth in plants that are fitted for it. The plants of the Coal period were made for that period. The sigillaria and calamites manifest, by their characters and mode of occurrence, that they could flourish only in a moist region; and the ferns of the tropics, as well as equisetæ, everywhere else, like moist woods. The lepidodendra, by their association with the sigillaria and ferns, show that the same conditions (as is now the case with their kin, the lycopodiaceæ) favored their development. In fact, lycopodiaceæ, equisetæ, and most ferns, are plants that like shady as well as moist places. Adding, then, the prevalent moisture and warmth to the excess of carbonic acid in the atmosphere, we should be warranted in concluding that even if there was less sunshine than at the present time, vegetable growth must have been more exuberant than now, especially in our colder temperate zones. This exuberance would not have shown itself in thick

* “Acadian Geology,” p. 422.

rings in trees, made for those very conditions, but, as through the existing tropics, under a moist climate, in the great denseness of the jungles and forests; many plants starting up where but one would have flourished under less favorable circumstances. Our peat swamps are often referred to as a measure for the growth of plants in the Coal era. But this is an assumption not based on a due consideration of the facts. The peat plants of the present day are species of the temperate zone alone, and are too different in kind to warrant a comparison.”*

Lyell thus accounts for the complete development of the flora of the Coal period: “The ferns of the Coal period had fewer rivals to compete with, and more space in which to develop themselves more freely; still, analogy would lead us to ascribe a luxuriant growth of ferns, many of them arborescent, to a period when the humidity and warmth of the air were great. The same may be said of the other vascular cryptogams, which, together with the ferns, form nineteen-twentieths of the carboniferous flora. They belong to families allied to ferns, such, for example, as the sigillaria, lepidodendra and calamites, and most of them attained a vastly greater size and had a more complex structure than any of their modern representatives. Their stems had also a lax tissue, and like living cryptogams of the same families they must have derived the greater part of the water which entered into their composition, as well as their carbon, by their leaves from the air.

* “Manual of Geology.”

They could only flourish, therefore, in an atmosphere highly charged with aqueous vapor, and such an atmosphere must have been warm. Yet we must not suppose the heat to have been tropical, *for hot sunshine, by promoting the decomposition of vegetable matter, is as adverse to the formation of coal as it is to that of peat.*"*

Now, if this foggy, damp, equable climate existed for hundreds of thousands of years, would the sun have been hid all this time? Would its warm and scorching rays never clear away the mists? and even if it did not, would not seasons of some kind come and go with their usual regularity? Then how can a shady, equable climate all over the globe be accounted for without the least change in temperature whatever? There is only one forced conclusion that, willingly or unwillingly, can be arrived at. *The sun itself had not yet been created.* The plants were nourished by the heat emitted from the centre of the earth, which had been sufficiently cooled to allow of their growth and development, by the covering of strata with which it was surrounded. This warm, equable climate would result in the formation of a heavy mist around the entire globe, owing to the amount of evaporation that would have taken place, there being no sun to carry it off. There would be no wind or storms to blow and smash down the reed-like and delicate plants of which the world's flora was then composed, for the earth had as yet no axial motion. The atmosphere which then

* "Principles of Geology," Vol. I., p. 226.

existed would have contained such an excess of carbonic acid that the very soil would be impregnated and saturated with it. This excess of carbonic acid would have a density so great that no aerial animal life could exist in it, while the existing vegetation would thrive and flourish. Aided by the heat and moisture then prevailing the vegetable growth would have a most rapid and exuberant development, unrivalled by any tropical growth of the present time. Plants would have sprung up like mushrooms, reaching maturity in twenty-four hours. The vegetation was simple and was made for the climate, and the climate exactly suited the vegetation. Under such favorable conditions there is nothing surprising in the rapid growth and ephemeral nature of the coal plants. The case may be explained by an illustration. Remove the coat from a potato, turnip or other vegetable of a similar nature, and place the vegetable in a dark, moist, warm atmosphere. In a comparatively short time afterwards the vegetable will be found completely covered with a rich, parasitic growth of mould. Examined under a microscope this mould is seen to be a magnificent world of vegetation, equally as luxuriant as that of the coal flora. Then if such a wonderful growth of fungus could exist on a body of material capable of producing it, only five or six inches in circumference, what kind of vegetation might not be expected from a vegetable-producing globe twenty-five thousand miles in circumference? By making a comparison between the two the vegetation of the Coal

period was no larger in proportion than the thick covering of mould on a decayed vegetable. Again, if the vegetation had an existence of thousands of years, how can the perfect condition of the fossilized plants found in the coal beds be accounted for? The impression of the leaves of the ferns, etc., are of the most accurate description; even the very veins of the leaves can be most distinctly seen and traced in the fossil material of that period. What is the reason these leaves did not rot and decay during the "countless ages" in which they are said to have existed? The leaves must have shrivelled and dried up, and falling to the earth would in a very short time have been converted into that element. But this did not take place while the plants were growing, for the fossils are as fresh as if the plants were already alive and existing. And coal is not composed entirely of decayed vegetation. In addition it contains a great quantity of soft, carbonaceous matter, and other impurities, and the remains of the vegetation found is of a most perfect nature, showing no signs of natural decay whatever. Therefore it must be concluded that their existence was very short, being limited to one or two days; and that they had not survived long enough to die a natural death, but were suddenly cut off by a catastrophe or other event, and their natural course of decay instantly arrested. The coal is simply the petrified, carbonated boggy soil in which the vegetation flourished.

It is a common occurrence to find the trunks of the coniferous and sigillarioid trees of the Coal period in

an upright or inclined position, on the place where they had formerly grown. These erect trunks have been completely imbedded in shales, clays and sandstones, and the interior of the stems filled with the accumulating *debris*, together with the remains of snails, reptiles and plants. How a tree of any description could remain upright for thousands of years while the surrounding material was slowly and gradually accumulating over its top is altogether inconceivable. The interior of the trunks must have been hollow in the first place, to admit of the sediment being washed in from above. If they had been decayed, and the interior rotted out through age, they would speedily decompose long before the accumulating sedimentary matter covered their tops. It is evident, therefore, that the trees were alive at the time the sediment began to accumulate, their interior being of a pithy nature. The accumulations must have been also very rapidly deposited, for unless quickly submerged the trees, either dead or alive, would rapidly undergo decomposition, which was not the case. The fluted trunks of the *sigillaria* are occasionally found pressed together and flattened so that the bark constitutes the horizontal layers half an inch or an inch in thickness. This would indicate that the plants were nothing more than gigantic reeds thrown down and pressed flat together during life by the rapidly accumulating material which caused their destruction, and not being first hollowed out by age and afterwards compressed. If the latter had

been the case the dry bark of the trees would have been broken into splinters and swept away ; but the compressed bark is found as perfect in every respect as the rounded trunks which retained their upright positions.

“ Remains of branches of plants have been found in the Ohio Coal measures by Dr. Newberry, with what has been regarded by Hooker as young or partially developed leaf buds attached.”* Then why did they never develop during the “countless ages” that are presumed to have existed ? They had no time to do so, for the transition took place too rapidly, and they were blotted out before they could attain their normal growth.

But how, it may be asked, could animal and vegetable life exist on the earth if there was no sunlight, even though the earth were warm and moist enough for their existence ? Animal life could exist in the same manner as it does at the present day under almost similar circumstances. Vegetable life abounds in caverns and subterranean regions where no ray of sunlight has ever been known to enter. It consists of fungi which shun light entirely and thrive in damp and darkness. Some of these are remarkable for their size, and have been known to attain from ten to fifteen feet in diameter. Moisture and warmth of air, however, are necessary for their existence, and they are usually found germinating on decomposed wood or some other basis of an organic nature. In such sub-

* Dana's “Manual of Geology.”

terranean regions animal life also exists in great numbers, such as crickets, spiders, scorpions, millepedes, crustaceans and beetles. In the underground rivers blind fish and other animals abound, which are never known to have existed in the waters of the outer world. Among them is the well-known proteus anguinus, with its long, eel-like body and four little legs—an animal which breathes through lungs and gills at the same time. The animals of the Coal measures were principally amphibian—an intermediate class between fishes and the true reptiles. The insects were such as could endure a similar climate at the present day, such as neuroptera, orthoptera, arachnida, coleoptera and myriapods.

It is well known that vegetable life can exist in darkness if the necessary heat is provided, and light is only an adjunct towards its development.

"We know by experiment," says Lyell, "that plants which are natives of the tropics can dispense more easily with the bright light of those countries than with the heat of the same. Few palms can live in our temperate latitudes without protection from the cold; but when placed in a hot-house they grow luxuriantly, even under a cloudy sky and where much light is intercepted by the glass and frame work."* If animal and vegetable life can exist and thrive under such conditions at the present-day, there need be no difficulty in understanding how they did so in the past, when the physical conditions in which they lived were specially adapted for their existence.

* "Principles of Geology," Vol. I., p. 225.

The close of the Carboniferous formation witnessed an event that almost completely exterminated all life that then existed on the face of the earth. This event was caused by a great oscillation of the globe, accompanied by an immense force that uplifted the coal beds and the formations beneath them, by which they were fractured, dislocated and thrown up in great undulations or flexures, while the strata were consolidated and debituminized, and the underlying rocks crystallized and fused. Though there were slight oscillations while the previous strata were laid, they were not general, nor did they cause any serious disturbance. Up to the time of the formation of the Coal deposits they had been laid down in their natural horizontal position, and in some parts of America they have escaped the effects of the succeeding disturbance, and still remain nearly in their original position. The fact, also, that stumps of trees have been found in their natural positions in the tilted coal beds shows that the layers must once have been laid down in a horizontal position. But at the close of the formation these strata were violently disturbed by some great force that raised and lowered its surface, and warped and bent the layers into great flexures and folds, some of them often many miles in extent. Not only were these curvatures formed, but in many places the strata were ruptured and dislocated, forming great fissures, which were filled up by the earth from above or the underlying rock beneath. The coal beds were formed when the land had been elevated just above the sea level ;

and the fact that these peculiarities occur similarly in Europe and America shows that the disturbing movement was a general one, and not at all local in character. From the appearances of the contorted flexures it is evident that the strata were of a plastic nature at the time in order to allow of the warping of the crust, and that the crust was just stiffening sufficient to cause the cracks, fissures and dislocations which then occurred.

Now, what wonderful event almost completely exterminated all forms of animal and vegetable life then in existence? What vast and tremendous force, travelling from west to east over the entire globe, upraised and lowered the crust of the earth, causing the gigantic upheavals and flexures which then took place? The answer must be, *the creation of the sun and the first revolution of the earth on its axis.* The very imprint of the earth's first motion can be traced in America, commencing in the north-west and gradually rising in gentle undulations toward the south-east, where they become more abrupt and pressed close together, until only a small series remain, or they become lost altogether as they recede towards the ocean.

With the advent of the sun and moon the swamps disappeared as if by magic. The axial motion of the earth submerged the low-lying lands beneath the waters of the ocean, after the delicate reeds and ferns had been cut down by the wind and laid in layers as though they had been mown with a scythe. The morasses were filled with sand, clay and *debris* from

the marine waters. Some of the largest and strongest plants continued to flourish until their tops were covered with sand. The oceans were then forming, currents were produced, tides were formed by the attraction of the sun and moon, the wind and the waves were in action, and in the commotion the land was constantly submerged and elevated alternately. The entire globe underwent a complete metamorphosis, and a succession of rapid changes took place. The vast bogs and marshes on which the vegetation grew were floated and whirled around by the forming currents, and buried layer after layer in sand and gravel washed over them by the ocean. This formed the intervening strata of the coal beds, which consist of sandstone, shale, iron ore or limestones. In the alternate layers are found fresh-water shells and marine remains, showing that the ocean completely covered the low-lying land. There need be no great difficulty in considering how all these changes could take place in twenty-four hours when the forces which were at work at the time are taken into consideration.

Thus terminated the first catastrophe that devastated the earth. It was the dividing point between Palæozoic and Neozoic times, the physical conditions which previously existed having forever disappeared, and an entire change of terrestrial surrounding, accompanied by a new creation of animal and vegetable life, ushered into existence.

CHAPTER II.

THE PRIMARY ROCKS.

PREVIOUS to the Carboniferous period the rocks constituting the Silurian and Devonian formations were laid down. The underlying or Azoic rocks are the only ones which completely envelop the globe. They are nearly all crystalline, flexed and disturbed, having at one time been in a universal state of fusion, showing them to be a direct result of igneous action. They were also completely enveloped in water, for the Silurian and Devonian rocks, which rest on them, are sedimentary beds of subaqueous origin, but afterwards solidified. The theory of the great antiquity of the earth has been chiefly derived from the enormous magnitude of these primary rocks, which in some instances attain a depth of several miles and cover a vast extent. The formation of these is supposed to have been effected by natural causes, such as those now in operation which produce like results. No change greater than that known by actual experience is admitted, and all extraordinary activity, or greater frequency of subterranean action than that of the present day, is excluded from the operations of these forces during all time past. By a combination of the action

of air and water the surfaces of the ancient rocks were supposed to have been worn down and the detritus deposited by currents of running water in stratified layers in the bottom of the seas and lakes then existing. Thus the sand thrown up by the waves on the sea shore, and laid down in layers along the coast, and spread out over the sea bottom for many miles, is pointed to as a simple example of the disintegrating process and the manner in which the primary rocks are inferred to have been formed. By the elevation of these deposits dry land appeared, and the remains of plants and animals found in these rocks are thought to have been buried in the accumulating stratifications which succeeded as a continued result of a slow and gradual disintegration. As the effects of this process during the past three thousand years are known by actual experience to be infinitely slight in comparison with the enormous magnitude of the primary rocks, it is held that the process of stratification must have been going on for immeasurable ages, and have occupied a period of time so remote as to be beyond the power of human comprehension.

The first sedimentary deposits bear unmistakable evidence of having been accumulated beneath a comparatively level stretch of water. There were no raging oceans and lofty mountains; no land with its mighty rivers and extensive plains from which these sediments could have been washed down to form the rocks of the Palæozoic period; no mighty upheavals or violent eruptions; and save a comparatively gentle

oscillation taking place on the surface of the earth all was quiet.

It is entirely inconceivable how the igneous forces by which earthquakes and other terrestrial phenomena are at present produced could have slumbered for untold millions of ages, when the surrounding rocks, both above and below the sedimentary strata, everywhere show traces of intense heat and fire. That no violent disturbance took place during their formation is shown by the fact that metallic veins and dykes in many instances interpose and penetrate completely through the entire beds, from which it is seen that the sediments were entirely accumulated before an eruption took place. That millions of years passed in this manner is contrary to all human knowledge of the operations of the same forces as existing at present. It is undeniable, too, that these forces acted with greater intensity at this primitive time, for the igneous nature of the rocks bears undoubted testimony to this fact. In the midst of such an igneous period, therefore, these sedimentary rocks could have had no other than a rapid and almost instantaneous origin.

With the two forces of fire and water actively at work, with an intensity sufficient to form clay slate and such similar substances, the primitive rocks, that would require an infinity of years to form by the disintegrating process, could have been produced in twenty-four hours as chemical precipitates. Heat and water were the elements engaged in the formation of

the Palæozoic rocks, and the effect of their consuming and destructive nature is well known.

The underlying granitic rocks, which had an existence before the sediments resting upon them had ever been formed, bear unmistakable evidence of having been produced directly by igneous action. "These have been purified by fire," says Winchell. "Everywhere do we find those massive crystalline rocks resting beneath the entire series of those which have been accumulated in the form of sediments from water, and which have buried in their common sepulchre the hordes of earth's pre-Adamite existences. These foundation-granites are bearing upon their Atlantean shoulders the weight of twenty miles of solid strata. They contain no organic remains. The granites of this class exhibit no evidence of having been produced from sediments. They bear the marks of fire. The devouring element has caused their stubborn sides to yield. They have been in a molten condition. You may take a fragment and fuse it in a furnace, and on suffering it to cool under circumstances similar to those in which the rock has been placed it resumes its rock-like aspect. Marks of heat are all about these granites and their trappean associates. Wherever they have come in contact with rocks of sedimentary origin the latter are scorched and reddened. In many cases they have been actually fused. A sandstone has been converted into quartz; a slate into a micaceous, semi-crystalline bed; a limestone into a statuary marble; and all vestiges of living forms which these strata en-

closed have been withered up and dissipated by the touch of fire."*

At this period of the earth's history there could have been no gradual disintegration from the "pre-existing" rocks, for the earth had not as yet attained its axial motion, and consequently there were no waves or currents to wash and grind down the rocks into layers of sand and other material of which the sedimentary beds are formed. The uniformity of composition of the Silurian rocks may be accounted for by chemical action. The surface of the globe was perfectly level and free from currents of wind or water, for only on those conditions could chemical depositions have taken place. There was no diversity of climate or of oceanic temperature all over the globe.

The animal and vegetable life existing on the earth during this period were of the lowest forms and all marine, no land or fresh water species being known. Among the former were mollusks, such as the ammonite, marine worms, and a tribe of crustaceans known as trilobites, creatures with a body of jointed plates, composed of three lobes, and with a single eye on the top of the head calculated to look upward from the bottom of the sea. During the Devonian period fishes were numerous, but of an entirely different nature from any known to have existed afterward. Among them were species of ganoids known as the pterichthys and coccosteus, covered with horny plates instead of scales, the former having two wing-like appendages

* "Sketches of Creation."

near the head, resembling paddles. The latter resembled an immense tadpole in shape. All the species present nearly the same characteristic features. The head is broad, the tail divided into two unequal lobes, and no indications of the bodies of the vertebræ are found, but merely the apophyses, or spinous processes, from which it is supposed that the skeleton must have been cartilaginous. The tails of the ganoids, or sharks, were vertebrated, while the bodies were not—a characteristic the reverse of fish of a similar nature at the present time. Their existence was short and brief. "They were not as fully developed as most of our fishes," says Agassiz, "being like the sturgeon, *arrested, as it were, in their development.*"*

This generally-admitted fact clearly indicates the rapidity of the creative process, and that they were suddenly cut off during that operation. If untold millions of years had elapsed there was plenty of time in which to complete their growth, and, if the theory of Evolution were correct, to evolve into some other animal. The vegetation of the period consisted principally of algæ, or sea-weed. Among the lower forms of life which figured conspicuously in Palæozoic times were corals; and it may be asked how they could have had a short existence when a long period of time is necessary for their growth at the present day. There is nothing in the extent of their work at this early period to indicate to the contrary. "They were conspicuous, not from what they *did*," says Hugh Miller,

* Agassiz and Gould's "Comparative Physiology," p. 400,

“but from what they *were*. . . . They were not built up under the direction of even an instinctive intelligence, but were as entirely the results of a *vegetative* process of mere growth as the forests or reed-brakes of the old Carboniferous savannas.”* If the corals grew for “untold ages” at this early period of the earth’s existence, their work should proportionately correspond in extent with the reefs of the present day. The fact that they had a mere existence only is indicative of the short period of time the primitive formations occupied in the geological history of the globe.

* “Testimony of the Rocks,” p. 237.



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